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August 2000
Vol. 21 No. 8

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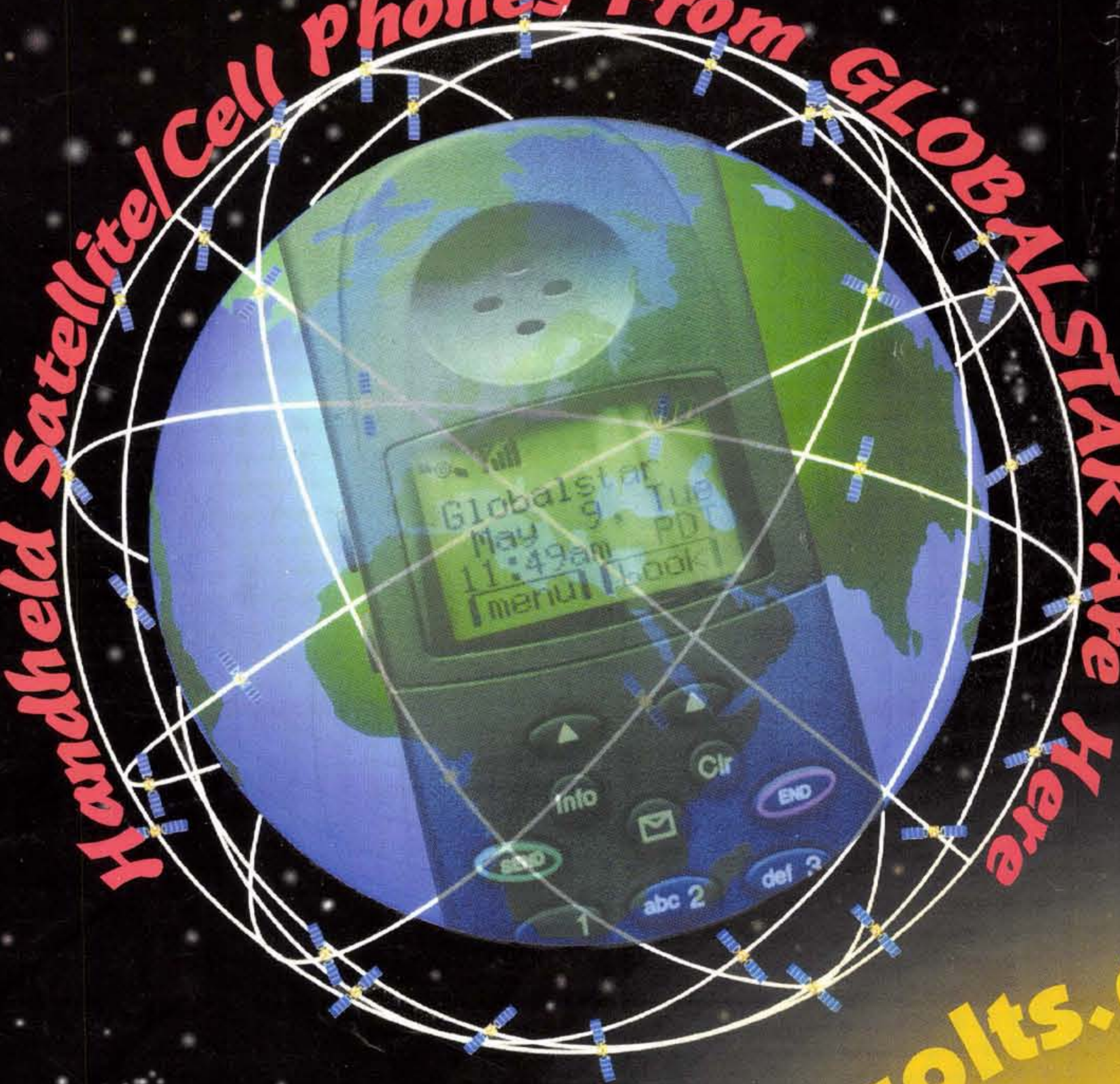


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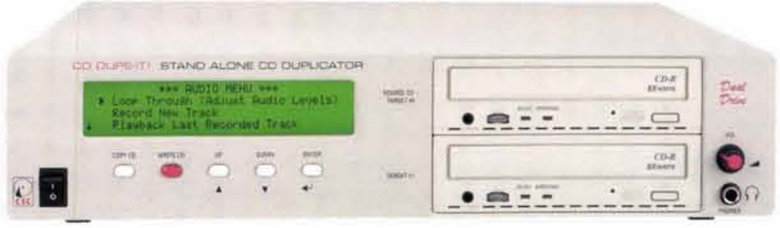


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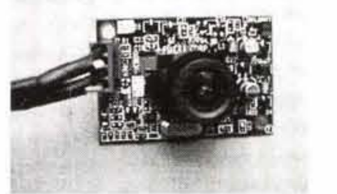

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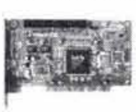

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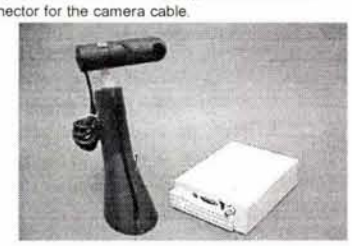

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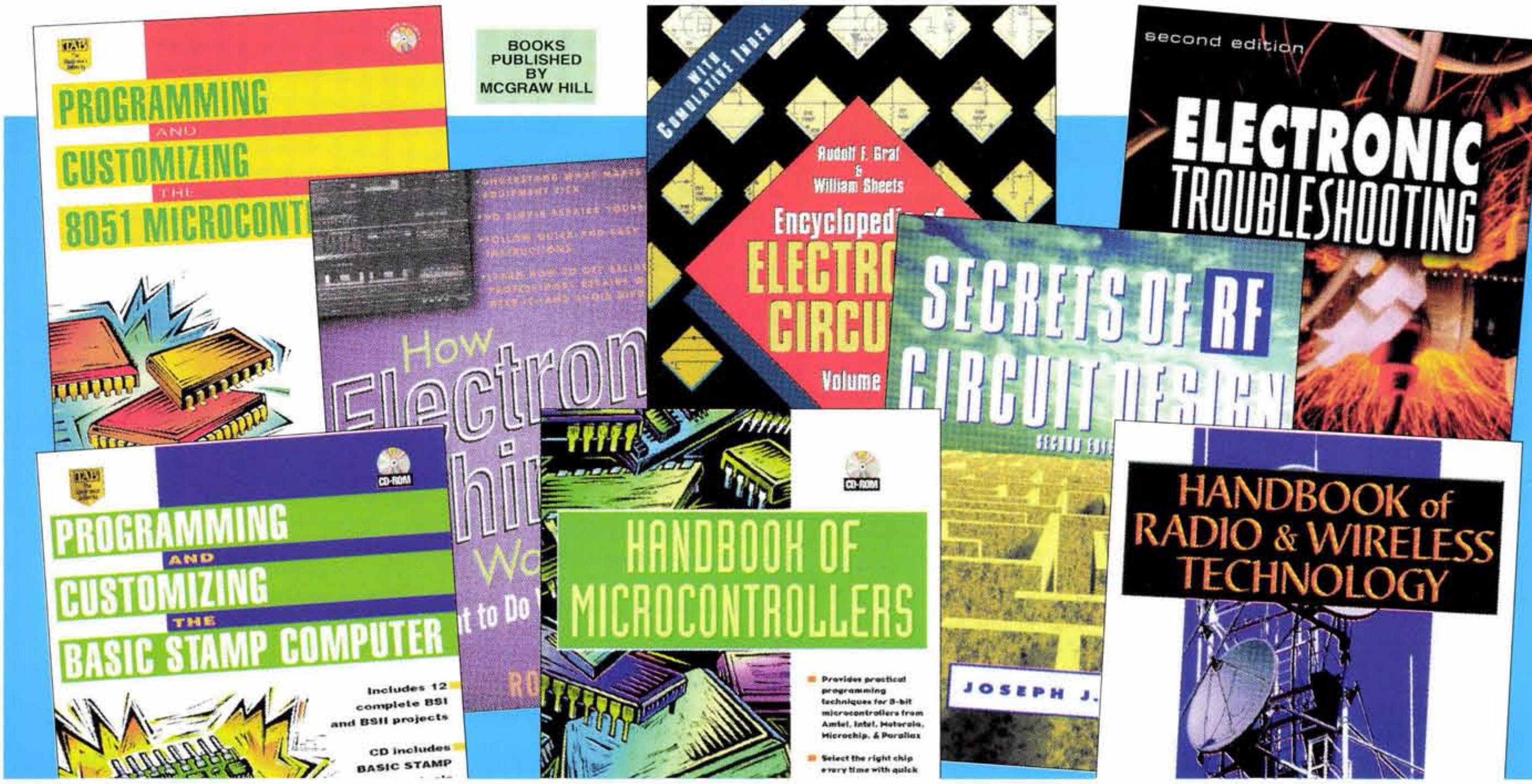


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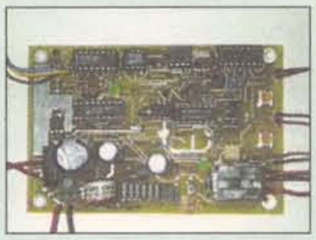

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# AMATEUR ROBOTICS NOTEBOOK

**by Robert Nansel**

This month, I finish the wiring and electronics for Jiffy, take a look at an unusual three-wheeled robot controlled by a Palm Pilot, and admire its wheels (even though they aren't made from peanut butter lids). I also have some historical and philosophical musings on the nature of hacking and the nurture of innovation, and I'll wind things up with some suggested summer reading.

### Jiffy Gets Wired

The first job is to mount the four AA-cell battery holders inside the front and rear chassis. The reason for two battery holders is to more uniformly distribute the weight between the front and rear chassis. This helps the skid-steer system work more predictably. Also, one pack powers the servos and the other powers the electronics.

I used double sticky foam tape to mount the holders. Clean the bottom surface of each battery holder (RadioShack #270-391) with alcohol, then roughen the surface with sandpaper or a file so the foam tape will adhere better.

Position and orient the battery holders with the ends of the holders pressed up against the inside wall of each chassis compartment and the wires facing inboard (i.e., toward the swivel; see Photo 3). Press firmly into place.

The second job is to drill the mounting holes for the power switch and the LED power-on indicator. The power switch is a DPDT submini center-off toggle switch (RadioShack #275-620A), and it requires a 1/4" hole for the threaded mount and an optional 1/8" hole 1/4" to the side for the registration tab. For the registration hole I drilled a 1/8" dimple, just deep enough to take the tab. The LED (RadioShack #276-018) comes with its own snap-in holder, and it requires a 5/16" hole.

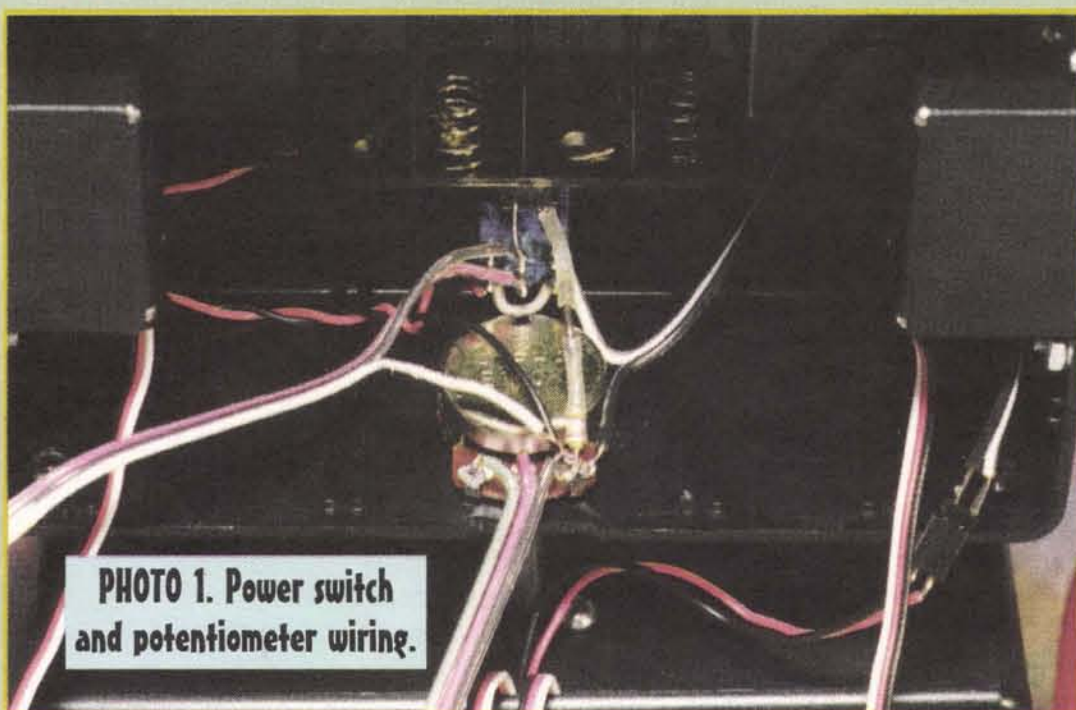


**PHOTO 1. Power switch and potentiometer wiring.**

I placed the power switch hole in the rear chassis by eye, on the centerline of Jiffy. I put it a little back from the tilt sense potentiometer so that the solder lugs of the switch would be accessible inside the box — about 3/4" from the front outside edge of the box. The hole for the indicator LED goes another 1/2" back from the center of the switch hole, but be sure the body of the LED holder will clear the front edge of the battery holder (Photos 1 through 3).

Instead of the nut provided with the switch, I used one of the new rubber caps to secure the switch. These caps (RadioShack #275-1596) fit over the toggle lever of submini switches and have threaded brass inserts that match the thread size. They also have a rubber O-ring seal, so between that and the rubber sheath over the toggle, the whole assembly comes out reasonably water tight.

### Sacramental Solder Smoke

In the spirit of keeping the robot simple and cheap (and buildable on a picnic table without AC power), I had intended to place most of Jiffy's electronics on a RadioShack project board. Accordingly, I wanted to do all the soldering with a butane soldering iron. However, I had never used a butane soldering iron before, and my first few attempts to solder with it proved disasterous.

No, I didn't set the table on fire or scorch my pants (though these are distinct risks with this sort of iron), but I did ruin a few project boards. It's hard to get the tip temperature low enough to prevent delaminating the copper pads. The particular style of board I used — RadioShack #276-158, one pad per hole — compounded the problem.

Soldering the pins of an IC socket was not hard, but the heavier pins of header connectors proved to be a different story. Even though I pre-cleaned the copper pads with a scrubbing pad and liberally applied flux paste, I never managed to get good solder joints before too much heat built up and the pads delaminated. The iron — a RadioShack #64-2182 — is rated for 10-60 watts, and the tip that comes with it is a little larger than I would ordinarily use for PCB work. A smaller 1mm tip is available, and perhaps that would have solved the problem (that and a bit more practice).

Whatever the ultimate solution may have been, I decided to obviate the problematic PCB soldering by falling back on a solderless bread-

## LISTING 1

```
'
'       CAL4SERV.BAS
'
'       Calibrate 4 servos
'

' Set up I/O bits

        DIRS = %1111111111111111        ' Make all I/O bits outputs
                                        ' Only bits 0,1,2, and 3 are
                                        ' connected.
                                        ' The rest are left as unconnected
                                        ' outputs to save power & prevent
                                        ' possible erratic operation

' Send 1.5 msec pulse trains to all four servos to calibrate STOP settings

main:
        PULSOUT 0, 750
        PULSOUT 1, 750
        PULSOUT 2, 750
        PULSOUT 3, 750

        PAUSE 10

        GOTO main

        END
```

board (RadioShack #276-175, Photo 4). This proves to be much more compatible with building on a picnic bench, anyhow — and quicker. Some soldering is still required for the power switch, power-on LED, and various cables, but it's easy to make these joints since they aren't as delicate.

### Point-to-Point

Photos 1, 3, and 5 show the general layout of wiring. I used one end-tap lug of the potentiometer as a convenient point to make all of the ground connections, and the solder lugs of the switch itself for the B+ connections. The rest of the wiring is accomplished with jumpers on the solderless breadboard as seen in Photo 4. The BS2 is on the left, in the middle are four three-pin header connectors for the Futaba servos, and on the right are two more three-pin headers, one for power (bottom) and one for the relative tilt sensor (top). The solderless breadboard is mounted to the bottom lid of the rear compartment (what I call the "brain pan").

Everything is connectorized so the two chassis boxes and the brain pan can be separated (see Photo 5). Three cables run from the front compartment to the rear: two ribbon cables for the servos and one for the battery holder.

Photos 2 and 6 show a fourth cable emerging from the rear chassis. This cable is the four-wire BS2 programming cable. It connects straight through to pins 1 through 4 of the BS2-IC. I added this cable because I got tired of opening the box every time I wanted to reprogram the BS2.

To accommodate the cable, you'll need to widen the slot the other cables run through. I used solid-wire ribbon cable, so the cable is just bent out of the way when not being used. If you are satisfied with your program, you can also tuck the cable away inside the box.



### A Different Servo Hack

Listing 1 is a brief bit of PBASIC code to allow you to calibrate your servos' STOP range. Most people modify servos for continuous rotation by replacing the servo potentiometer with a fixed resistor voltage divider. This works fine, but for Futaba servos, there is an easier way that's less intrusive and much more convenient.

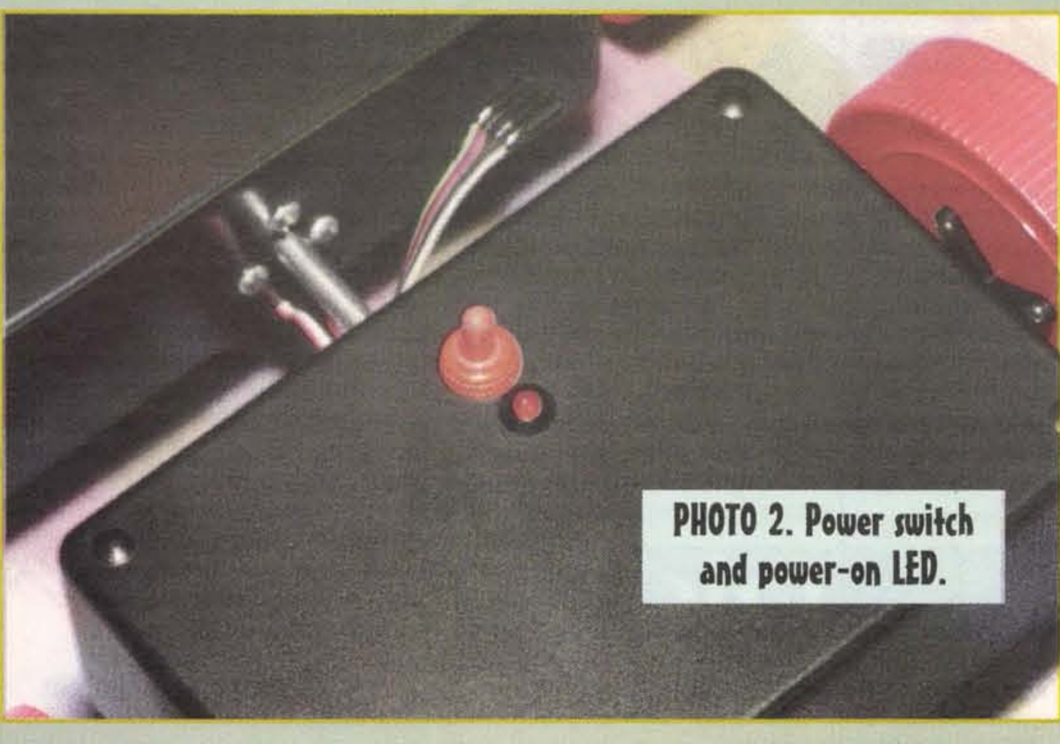


**PHOTO 2. Power switch and power-on LED.**

Dismantle the servo as normal, but leave the bottom plate and circuit board undisturbed. The output gear/shaft of the servo has a silver-gray bearing ring in its hollow underside, and beneath that ring is a slotted nylon coupler that the potentiometer shaft rides in. With a little bit of levering, you can easily pop the bearing ring and slip the nylon coupler out. Set aside the nylon coupler (save it if you ever want to convert the servo back to ordinary operation), and press the bearing ring back into place. Shave off the mechanical stop lobes on the upper side of the output gear as usual. Repeat this process for the other three servos.

Now, instead of putting the output gears back and reassembling the servos, leave the tops off so the feedback pot shafts are visibile. Connect the servos to Jiffy's brain, download CAL4SERV.BAS, and run the program. All the program does is send 1.5-msec pulsetrains to each of the servos. The motors for all four servos will probably start running.

Tweak the feedback pots of each until the motor stops. Reassemble the servos without disturbing the pot settings (the pots have a fair amount of friction, but you can put a drop of hotglue on the pot shafts to hold them more securely, if you like). That's it.

(Next month, I'll get into software to really give Jiffy a workout.)

### Omnidirectional Drive

One of the bonuses of being a member of the Seattle Robotics

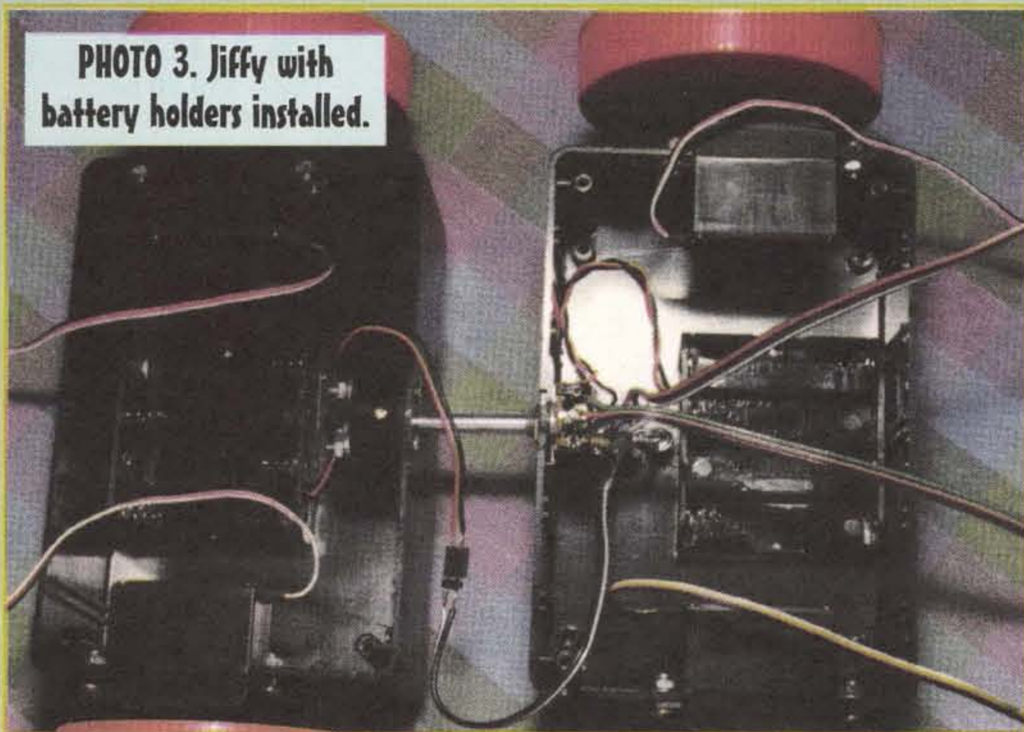


PHOTO 3. Jiffy with battery holders installed.

Society list server is that I find out about cool robot links that other people come across, many more links than I even have time to investigate each month. If you aren't a member of the SRS list, you should be. It's free, and it's one of the best sources of ideas and how-to information on amateur robotics on the web.

To join, go to the new SRS list site at www.egroups.com/invite/SeattleRobotics and click the "JOIN" button. You may also visit the eGroups web site to modify your subscription: www.egroups.com/mygroups.

Anyway, because of the SRS list, I heard about a particularly interesting robot: the Palm Pilot Robot which uses a *holonomic* drive system. A *holonomic* drive is drive where the robot's translation and rotation on a plane surface are independent of each other. The vector sum of the rotational vectors of all the wheels determines the direction and speed of the robot's translation and rotation. In other words, the robot can position itself anywhere on a plane in any orientation. The robot accomplishes this using three servo-driven omnidirectional wheels.

Omnidirectional? That's right, it uses wheels that roll in the normal way, but they also roll from side to side — roller wheels which permit 360-degree multidirectional movement. To see what I mean, take a look at www.cs.cmu.edu/~reshko/PILOT/

The nifty thing about these wheels is they cost only $5.00 each. You can also use these wheels to replace standard swiveling caster wheels. You can find information on these wheels — called Trapo-brand All-Side Rollers — at North American Roller Products, Inc., P.O. Box 2142, Glen Ellyn, IL 60138-2142. You can also call them at (630) 858-9161. The contact I spoke to was Jerry Miller, and he can be reached at jhmnarp@aol.com. Now, Jerry told me his company's wheels aren't really intended to be used as drive wheels; they are really only meant to be used on product conveyers. But they sure look worth a try. (Sorry, no website for this company.)

But back to the Palm Pilot Robot. As it turns out, the people who designed the robot are local to me at Carnegie Mellon. Though they are just 20 miles up the Ohio river from the Robot Ranch, I would have likely never stumbled across their website on my own if it hadn't been for the person who posted the URL to the SRS list. This points out how important the new virtual gathering places — such as the SRS list — can be.

**Invention and Place**

Histories of innovation usually concentrate on the end product — the successful invention or the brilliant inventor. But this approach to history tends to obscure the process of innovation itself. No innovation occurs in a vacuum; all great innovations have as background the places, institutions, and times that drive the process. Some of these places were extraordinary, but too often, little is known of them.

Boston in the 60s and 70s was such a place, the fulcrum of a technological revolution that we are reaping the fruits of. The institution was the workshop of Charles Williams, Jr.

Williams, a successful independent engineering consultant, employed 25 talented technicians and specialists at 109 Court Street, where his R&D facility occupied the entire third floor. The building was shabby, but the rent was cheap. What he saved on rent he used to equip his lab with the best equipment and materials he could buy. Williams often took on "White Knight" consulting contracts.

In the consulting business, a "White Knight" is a consultant brought in by a company to troubleshoot a hopelessly mired engineering project. It's risky work, but Williams enjoyed pushing the envelope; when successfully concluded, these projects almost always meant more business for his shop, either in new referrals or in short-run manufacturing of finished products. If his success could be summed up in three principles, they would be: 1) Stay small; 2) Hire the best; and 3) Stay current.

But sometimes the story of a man can better be told by the stories of the people around him. In the midst of the turbulence of the war and the civil rights struggles of the 60s, many businessmen of his generation scorned the rebellious

**If you have suggestions, questions, or comments about amateur robotics topics or, if you want to come to High GEAR, you can reach me at:**

**Robert Nansel**
**Box 228**
**Ambridge, PA 15003**

**E-Mail:**
**bnansel@nauticom.net**

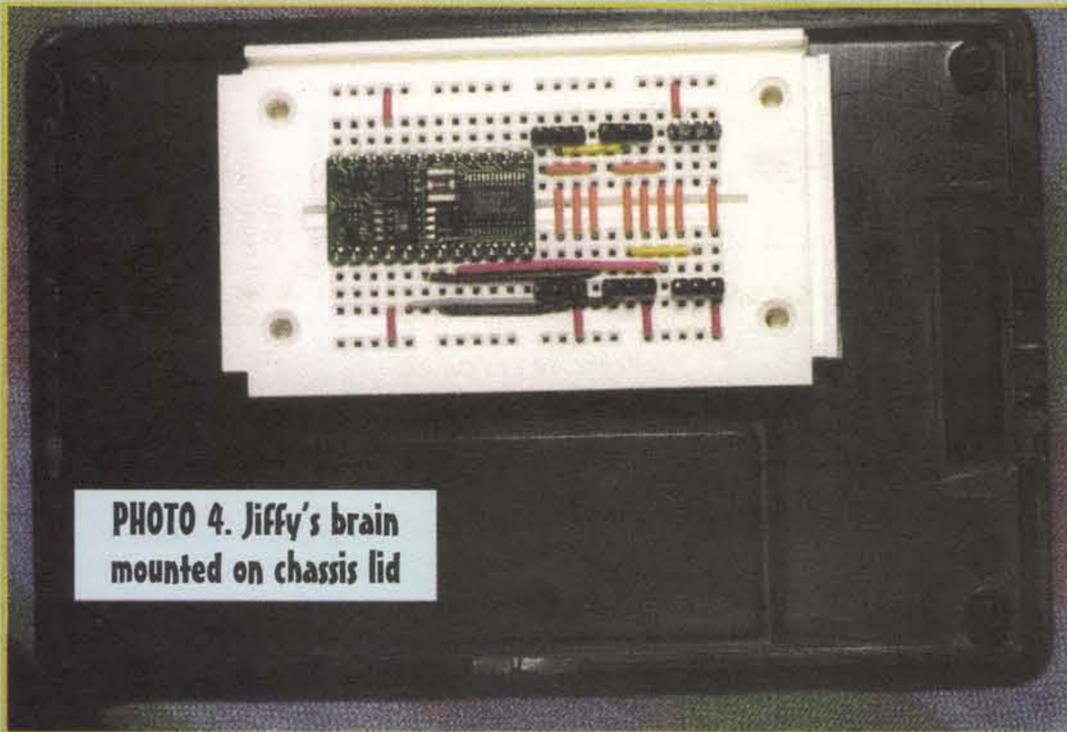


**PHOTO 4. Jiffy's brain mounted on chassis lid**

youth of America, but Williams actively embraced them. Williams especially had a soft spot for young hackers, and his workshop became a haven for them.

They came to his workshop to talk, to listen, and to dream, and some of them eventually even went to work for him. Students and dropouts, drifters and dreamers, they came and shared their visions of a better tomorrow, their hunger for change.

**A Hacker Named Al**

One hacker, known by his friends as "Al" was an oddball by any definition. He'd dropped out of school and had subsequently lost or quit every job he ever had, too lazy – to his parent's dismay – to make it in corporate America. In Boston, Al worked just hard enough at his day job to keep from getting fired. He lived on junkfood (pie was his favorite), kept late hours, and it showed. In his early 20s, he was rough, spoke poorly, and lacked most basic people skills. He was, in a word, a nerd.

Al found in Charles Williams and the people surrounding him the technical and emotional nourishment that he needed to transform himself. He rubbed elbows with techies with far more education than he, but at 109 Court Street, what mattered was the quality and workability of your ideas, not the level of your education.

Al was inspired by everything he saw and heard at 109 Court Street. In the nutrient medium that Williams provided, Al's native genius overcame his laziness and lack of education. Though he never understood people, he understood the *technology.* He began his own consulting company in the late 60s, a time when the idea of the information appliance and digital networks were just being born. He concentrated first on data communication equipment, earning the admiration and dollars of business people who increasingly came to depend on the new "boxes" on their desktops – and on Al's guru-like ability to debug them. From there he branched out to recording, multimedia, and lighting systems. His story has become the classic of the garage-hacker-to-billionaire-entrepreneur genre.

**A Hacker Named Alec**

Another hacker, a foreign student from Scotland, came to 109 Court Street a few years later in the 70s. His name was also Al, though he preferred to be called Alec. Where Al was unkempt and rough, Alec dressed well and was anything but a nerd in appearance. He was a well-educated, polished man who spoke eloquently on many topics. He was about Al's age, but looked older. Alec mixed easily with the liberal elite of Boston.

But Alec – like Al – was a night owl. He was a radical, exploring the fringes of perception and expression. He taught in an experimental school during the day and at night tinkered with exotic telecommunications hardware, filling his apartment with various "blue boxes," "red boxes," and "black boxes." He was the original phreaker, and his goal was nothing less than the overthrow of America's telecommunications megacorporation.

For all his education and polish, Alec was not as technically able as Al. He depended on the Court Street scene not only for his raw materials and equipment, but for technicians to build what he visualized. His first assistant was George Hamilton, a man "loaned" to him by Moses Farmer, a sometime military contractor who frequented Williams' workshop.

Farmer, an establishment engineer (but a hacker in spirit), depended on Charles Williams' firm for quick-turn engineering prototypes and advanced materials. Among other things, Farmer was working on improving torpedos for the Navy. Two years after the economy soured in '73, Farmer decided to close his Boston operations to concentrate on his torpedo contracts in Newport, RI. He took George Hamilton with him, so Alec had to find someone else to help him build his increasingly

**PHOTO 5. Completed Jiffy prototype, ready to be tested.**

sophisticated gear.

He went to Charles Williams for help. Williams assigned Tom, his best technician, to Alec, and thus Hamilton lost his chance for fame and fortune. With Tom's help, Alec's ideas finally bore fruit a year later. Along with Alec's venture capitalist, their's was to become yet another story about two guys in a garage starting a Fortune 500 company.

For both Al and Alec, the influence, encouragement, and technical support of Charles Williams was crucial; 109 Court Street in Boston was the nexus of change. Throughout history, certain places and people have been central to change – places like Detroit for the automobile, Silicon Valley for semiconductors, Coalbrookdale for steam engines.

The technologies that germinated at Charles Williams' 109 Court Street shop are no less momentous in their effects on our lives, but the place and the man aren't well known. We remember the people he encouraged, people like Al and Alec.

If we understand fully what happened at 109 Court Street, if we can feel the atmosphere of that place, we have a chance to make it happen today for amateur robotics. With the World Wide Web, physical places aren't quite as crucial as they once were, but robot builders still need hacker-friendly places – real and virtual – to exchange information, to buy leading-edge supplies, and to share the energy of like-minded gearheads. Most of all, we need the spirit that drove Al and Alec to create.

Al and Alec? You most likely know them as Thomas Alva Edison and Alexander Graham Bell; their times were the 1860's and '70s. And, as Paul Harvey would say, now you know the rest of the story.

**Summer Reading**

I have several books I want to mention, but only room for one. The one will be a great little book, *Personal Robotics: Real robots to construct, program, and explore the*

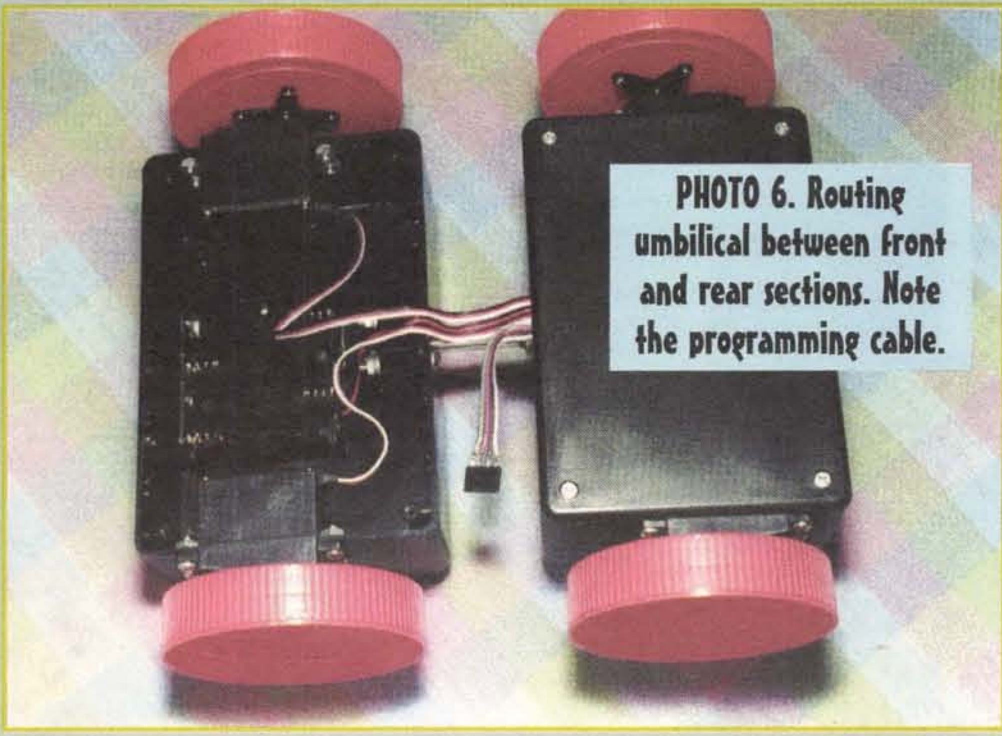


PHOTO 6. Routing umbilical between front and rear sections. Note the programming cable.

*world* by Richard Raucci (AK Peters, Natick, MA, 1999, ISBN 1-56881-089-X). The author of this book doesn't tell you how to build robots, he gives reviews of beginner, intermediate, and advanced robotic kits available on the market.

Raucci talks about Capsela, LEGO MindStorms, Learning Curve's Robotix, among others in the beginner's realm, the offerings of BEAM Robotics, OWI Elekits, Robix, FisherTechnik, and Rug Warrior Pro in the intermediate range, and the Pioneer series of robots marketed by ActivMedia for the advanced range.

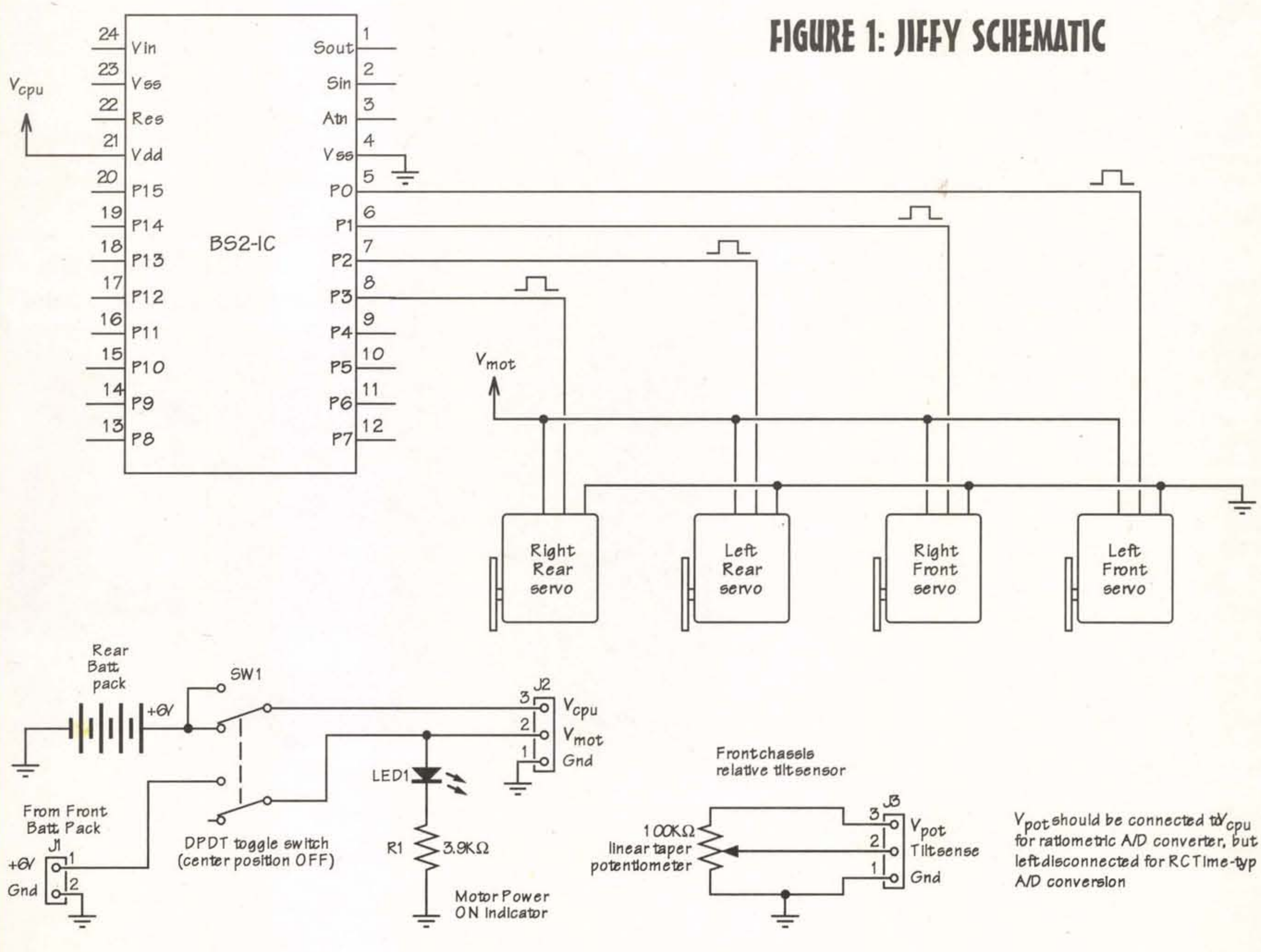
I was prepared not to like this book because I have a low opinion of a couple of the kits Raucci discusses, but I came away favorably impressed. Raucci is quite up front with the capabilities and limitations of the various kits he covers. I would have liked to see a few more advanced robot systems, and there was no coverage at all of legged robot systems. Still, Raucci won me over.

A nice touch is his thought-provoking introduction to robotics in Chapter One. This pointed me toward the short story "The Artist of the Beautiful" (also known as "The Mechanical Butterfly") written in 1844 by Nathaniel Hawthorne. For all the flowery 19th century prose, this story is well worth downloading. In it, you'll meet Owen Warland, who is a watchmaker — and builder of robot butterflies!

The dream has indeed been around a long, long time. You can find the story in the Hawthorne anthology *Mosses From an Old Manse* as a free e-text at the Project Gutenberg website (www.gutenberg). Enjoy.

Next time: more Jiffy & coverage of High GEAR (wherein Jiffy goes camping & gets muddy). **NV**

FIGURE 1: JIFFY SCHEMATIC




Write in 175 on Reader Service Card.

# Newsbytes

## TDK BRINGS NEW VELOCITY TO CD BURNERS WITH THE NEWEST VELOCD REWRITER

Rip, Rock and Roll performance helped make TDK's first veloCD™ burner a runaway success with music-passionate PC users. Now, TDK takes performance to the next level with a new veloCD burner that boasts the world's fastest writing (12X), rewriting (10X), and audio ripping (24X) speeds. TDK adds to this the power of fail-safe write assurance technology, which eliminates buffer underrun errors to create the world's first multitasking-compatible CD burner.

The new veloCD burner offers bit-perfect 24X digital audio ripping. Ripping or digital audio extraction is the necessary first step in all CD recording operations. Ripping with a typical CD-ROM or DVD-ROM drive is often slow and inaccurate, sometimes yielding audible clicks and pops in the CD copy. With 24X ripping and 12X writing, the new TDK veloCD burner offers a one-drive alternative for CD-to-CD-R recording that's better sounding and takes less than half the time of most two-drive setups.

### No More CD Coasters

Also key to the superior reliability of the new veloCD burner is the inclusion of BURN-Proof™ write assurance technology, which eliminates buffer underrun errors. These errors — which are fatal to the writing process — result from momentary interruptions in the data flowing to the write laser. They typically occur when the user tries to perform another task during the writing process or when the source cannot supply data fast enough to the writer.

To prevent buffer underrun errors, the veloCD continuously monitors the status of its built-in buffer memory. When a buffer underrun error is about to occur, the veloCD suspends recording until the buffer is re-filled. To continue recording at the appropriate place, the veloCD drive compares the recorded data with the data in its buffer and synchronizes adjacent frames. With this technique, the drive restarts recording at exactly the precise position where recording was originally suspended ... no more failed sessions ... no more CD coasters.

### The Fastest CD ReWriting

CD rewriting is becoming an important tool for day-to-day data backups. A dramatic advance over conventional CD rewriters, which typically max out at 4X, the new veloCD burner is capable of 10X rewriting with the convenience of drag-and-drop recording.

To achieve full 10X rewriting speed, it's necessary to use a new generation of TDK CD-RW discs. Easily identified by their high-speed logo, the new TDK CD-RW discs use a specially formulated phase-change material to achieve the ideal combination of high sensitivity and long-term data stability. Like conventional CD-RW media, the new high-speed discs can be recorded and rewritten more than a thousand times with no loss in data accuracy and reliability.

The new veloCD burner is about 40% faster and has more than three times the storage capacity of a ZIP disc and is the ideal medium for larger multimedia file backups.

### Ultimate Music Management and Recording Software

Designed as an all-in-one solution for CD music and multimedia recording, the new veloCD burner comes complete with music management and recording software.

***Digital Mixmaster*** gives users a convenient jukebox interface, easily customizable with a broad range of colorful graphic "skins." It handles day-to-day music management and recording functions including CD playback, ripping, MP3 playback, Internet-accessed track labeling, and CD recording (including on-the-fly conversion of MP3 music files and playlists into play-anywhere CDs).

Also included with the new veloCD internal ATAPI/EIDE burner is ***Nero 5.0*** multimedia recording software. Nero makes it easy to copy virtually every type of CD-ROM and CD-Audio disc, including multisession discs and several new hybrid formats. Nero can even control two veloCD burners simultaneously, making it easy for corporate users to convert their desktop PCs into a flexible duplication station.

TDK's 12X/10X/32X internal ATAPI/EIDE veloCD burner will be available this August at a suggested retail price of $349.00.

*BURN-Proof is a registered trademark of Sanyo Electric Co., Ltd. (Japan).*

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## RECORD RADIO SHOWS ON YOUR PC ... WITH CYBERCORDER 2000

Skyhawk Technologies announces the availability of Cybercorder 2000, a program that lets users record radio shows or any sound input on the PC hard disk drive.

Cybercorder 2000 allows you to use your PC like a VCR to schedule audio recordings. Simply connect the output jack(s) of the audio source to the input jack of your sound card, adjust the Windows mixer, and you are all set to record. Cybercorder 2000 lets you record with any of the audio compression formats, sampling rates, and frequencies available on your system to save disk space. Recordings are saved on disk as standard .wav files.

You can play back a recording by selecting one from the list of completed recordings. You can easily advance a recording forward and reverse by various step sizes using the customizable playback window. You no longer have to miss your favorite radio shows with Cybercorder 2000.

Cybercorder 2000 costs $19.95 for a single-user license. Site licenses are available. For more information, visit the Skyhawk Technologies web site at:

**skyhawktech.com** or write to:
**Skyhawk Technologies**
3166 Neptune Drive, Riverside, CA 92503
Voice: **(909) 688-8923** Fax: **(909) 637-0296**
Email: **info@skyhawktech.com**

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## iTestApps.com UNITES SOFTWARE DEVELOPERS AND BETA TESTERS

Fineware Systems announces the launch of iTestApps.com, a web site and newsletter that bring together companies looking for beta testers for their software, and individuals interested in participating in beta testing projects.

Beta testing is a crucial phase of the software development cycle that allows a pre-release version of a new program to be tested under real-life conditions by potential users. Until now, it has been a challenge for software developers to find a team of qualified testers with the proper mix of computer skills, hardware, and operating systems to ensure that their new programs have been tested in a wide variety of environments.

For a $300.00 listing fee, iTestApps.com helps companies locate qualified beta testing volunteers. iTestApps will include a description of the company's beta testing needs in six issues of the twice-monthly iTestApps newsletter which


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is sent to end-users seeking beta testing opportunities. In addition, the company receives four insertions of its New Product Announcement in the newsletter, once the beta testing has been completed, and the new software released.

iTestApps gives beta testers a chance to look at new software, with leading-edge programming interfaces and techniques, months before it will be available to the general public. The iTestApps newsletter is free for anybody who would like to consider becoming a beta tester. Beta testers are invariably rewarded with free copies of the final programs when they are released.

The iTestApps newsletter listing costs $300.00 for commercial software developers, less for shareware and freeware developers, and multi-use discounts are available. For more information, including online FAQs for both companies looking for testers and individuals who want to become testers, visit **www.iTestApps.com**, or contact iTestApps' parent company:

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Phone: **(405) 943-4533**
Fax: **(405) 942-7819**
Email: **fineware@fineware.com**

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## RECORD YOUR PHONECALLS TO HARD DISK ... FREE ... WITH VERITAPE

Blue Starfish Ltd. has released Veritape 1.3, a Windows 98/95 program that lets you record your telephone calls straight to your hard disk — all you need is a PC, a voice modem, and Veritape, and it's free!

Once Veritape is installed, you just click Record and talk as normal. No special telephone or other equipment is required. Store your important business negotiations, create a permanent record of your voicemail messages, tape family news so you can play it to others. You no longer need to make notes while trying to pay attention to the call, and you'll avoid the embarrassment of forgetting what you were told (or even what you said!). Veritape stores your calls digitally, with a description to allow you to find them again easily. You can play back your calls at any time, or email them to a friend or colleague.

Veritape is free for personal use, but organizations are required to buy Veritape if they install two or more copies. Veritape can be downloaded from **www.veritape.com**.

Organizations or individuals who buy Veritape (it costs US $30.00), can remove the advertising within the program, and use two bonus features: Veritape will compress calls into your choice of format, and can automatically email them. In addition, registered users receive priority support and free upgrades for a year.

For further information, see the Veritape website **www.veritape.com**, or email **info@veritape.com**. (The site also covers the legal implications of recording calls.) For information on multi-copy licences contact **sales@veritape.com** or mail:

**Blue Starfish Ltd.**
Alkrington Hall West, Alkrington, Manchester, M24 1WD, UK

# reader FeedBack

### Superbot 2.1

In your April 2000 (Vol. 21 No. 4) issue you advertise Superbot 2.1 software for Website downloads (Page 21). I downloaded the software to give it a try (URL has changed to http://www.sparkleware.com/index.html). The software is a "mole." It appears to grab personal data from your PC and upload it to (?). As soon as the software sees an open internet connection, your PC's hard drive and modem go to town ... without advising the user what it is doing.

This is unethical development in the least and you should consider action against the company that posted the article, before it reflects poorly on N & V.

**Anonymous**
**via Internet**

*Response:*

*This accusation has absolutely no basis in fact. SuperBot version 2.1 does not, and never did, upload any personal data from your computer to any location.*

*The current version of SuperBot, v2.3 beta, incorporates third-party technology to display advertisements in the program. This tool prompts users of SuperBot for some basic information, such as age and gender, and this information is used to determine which types of advertisements are shown. Although we did not design this technology, we are familiar with its mode of operation, and we have absolutely no reason to suspect that any covert transmission of any personal information is taking place.*

*I cannot even guess why anyone would spread such a rumor, except perhaps to damage SuperBot's reputation as the world's best offline browser.*

*(I believe a similar smear campaign was recently conducted against a product named Go!Zilla.) If you would like more information on the SuperBot v2.3 advertising module, please see the Cydoor Technologies website at* ***http://www.cydoor.com****.*

*Again, SuperBot v2.1 NEVER uploaded ANY DATA of ANY KIND to ANY LOCATION.*

***Chris Marshall***
***EliteSys***

### Telephone Busy Light

I am happy to see all the feedback on the Telephone Busy Light and its subsequent letters, and I must own up to the errors pointed out by Mr. Stiles. My letter quoted a minimum 10 megohm DC resistance, a figure I retrieved from my 1977 photocopy of the Part 68 regulations (47 CFR 68). Ten megohms is the old value; the FCC has relaxed the requirement to 5 megohms. This DC resistance must be met for all potentials less than 100 volts. The 1977 FCC rules also included the DC resistance in the definition of REN, but the modern rules do not, so Mr. Stiles is again correct. I should have used the current regulations. The old specification was the basis for my large RENs.

CFR stands for the Code of Federal Regulations, and title 47 is the FCC rules. Your local library should have a copy in its reference section, or you can view it on the web at many sites. The FCC has a quick search at **www.fcc.gov/mmb/asd/bickel/47CFRrule.html**; the GPO maintains **www.access.gpo.gov/nara/cfr/index.html**. I encourage everyone to go to the source.

Mr. Harkey's circuit presents a 4.7M DC resistance (if the diodes have no leakage current), so it fails the 5M requirement. The resistors should be larger. From an engineering standpoint, we must include the diode leakage current and make sure the total current at 100V is less than 20 microamps, but a single 1N400x rectifier may leak 10 microamps. It may be better (and cheaper) to move the series resistors to the other side of the rectifiers and use signal diodes. In any event, tip and ring should have series limiting resistors with 400V ratings to withstand line surges.

Maybe a line surge shorted out Mr Stiles' RadioShack 43-443, but his comments raise another issue about that unit. Mr Stiles said that it draws 1.9 to 3mA from the phone line when it is off hook. If several units are on one phone line, do they refuse to release the line after a call? Do they get dim? One of my phones has a self-powered busy light, but it flashes at a very low duty cycle, and its current draw should be much less than 1mA.

**Gerald Roylance**
**Mountain View, CA**

*Continued on page 81*

# Open Channel

by Joseph J. Carr

## VLF Radio

In past editions of this column, I have written about ELF, VLF, and LF radio in conjunction with RadioScience Observing. That is, the observation of radio phenomena in the ELF, VLF, and LF portion of the radio spectrum (5 KHz to 500 KHz). This month, I want to spend a little more time on the topic.

### What Are ELF, VLF, and LF?

The ELF, VLF, and LF portion of the radio spectrum are those frequencies between 5 KHz and 500 KHz. In general, about 5 to 20 KHz are considered ELF ("extremely low frequency"), 20 to 100 KHz are considered VLF ("very low frequency"), and the rest of the spectrum (100 to 500 KHz) are considered LF ("low frequency").

The Europeans have been using LF bands for AM broadcasting for years. These stations are found on 145 to 285 KHz. A notable station, often audible in the USA, is Radio 252 on 252 KHz. It runs about a 1,000,000 watts. In the middle of winter, especially, these stations are often audible in the USA and Canada. The Europeans call these frequencies "long wave."

The VLF and LF portions of the spectrum are also home to US Navy communications, WWVB (the National Institute of Standards and Technology radio station at Fort Collins, CO) on 60 KHz, and between 160 and 190 KHz a group of people called LowFers. These stations operate under Part-15 of the FCC Rules and Regulations, and are limited to 1 watt of RF power and an antenna length of 15 meters. They have demonstrated some amazing ranges given the limitations they work under.

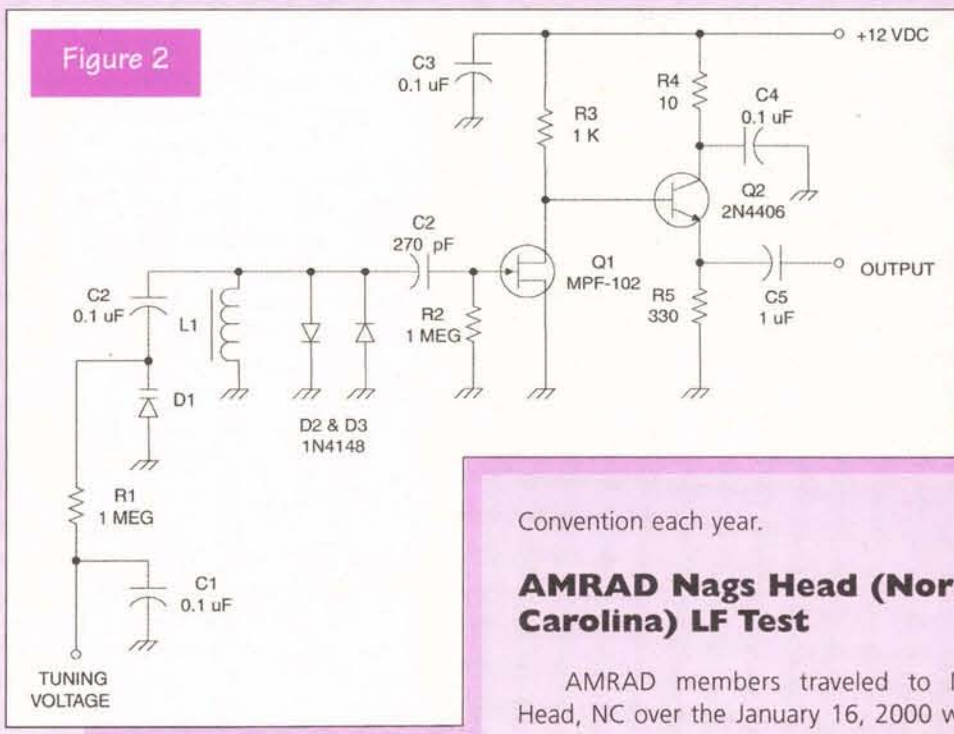
Beginning at about 200 KHz, and continuing up to 420 KHz, are a number of Non-Directional Beacons (NDB). They are located near airports to aid navigation using airborne direction-finding equipment. NDBs tend to run about 200 watts of RF power into a simple Marconi antenna, with some coastal stations running 2.5 kW to reach further out to sea.

The frequencies in the ELF and VLF region are peculiar, especially the lower frequencies (5 to 30 KHz). These frequencies are often used for detecting solar flares and sudden ionospheric disturbances (SIDs). It seems that the level of distant stations goes up, not down, during a SID event. The same SID event that will wipe out the shortwave spectrum will enhance the ELF/VLF signal.

It does this neat trick by ionizing the ionosphere down through the D-layer. Because these frequencies have very long wavelengths, the distance between the bottom of the D-layer and the earth's surface form a waveguide. This is the reason why the ELF/VLF signal strengths increase ... waveguides are very good conveyers of electromagnetic energy!

The wavelengths of ELF, VLF, and LF stations are amazingly long. For example, at 10 KHz, the wavelength is about 18 miles long. At 76 KHz, it is about 2.46 miles, and at 137 KHz (the site of a future amateur radio allocation), it is 1.3 miles. A quarter wavelength vertical on 137 KHz would be 1,800 feet long!

The Longwave Wireless Club of America **(http://www.lwca.org)** is active in ELF, VLF, and LF Dxing and their magazine – *The Lowfer* – is obligatory for anyone doing any work in the region.




### LF Transatlantic Challenge

The LF Transatlantic Challenge is provided by the Amateur Radio Research and Development club **(AMRAD, http://www.amrad.org)**, and is in honor of the late Peter Bobek (DJ8WL/DA0LF) in honor of his work on 160 meters and 137 KHz. The challenge is actually collectively sponsored by Deutsche Amateur Radio Club (DARC), AMRAD, and the Radio Society of Great Britain.

Two pairs of trophies will be awarded, one for each pair of amateur radio stations who make the first confirmed two-way LF transatlantic QSO on the 136 KHz amateur radio frequency allocation. The contact must be between a station on the North American continent (Canada or USA), and Europe (defined as continental Europe, Great Britain, Northern Ireland, and the Republic of Ireland). Here are the details:

**1.** An award will be granted to the first USA station and the first Canadian station (two awards) to receive a European 136 KHz station.

**2.** An award will be granted to the first European amateur station to receive either a USA or Canadian 136 KHz station.

**3.** The Challenge involves a pair of trophies for the first two-way Europe-USA 136 -KHz contact (once the band is allocated to amateurs by the FCC).

**4.** A pair of trophies will be awarded for the first Europe-Canadian 136 KHz contact.

**5.** Prior to the award of the trophies, certificates will be awarded to the pair of amateur radio stations who currently hold the distance record for two-way QSOs on 136 KHz.

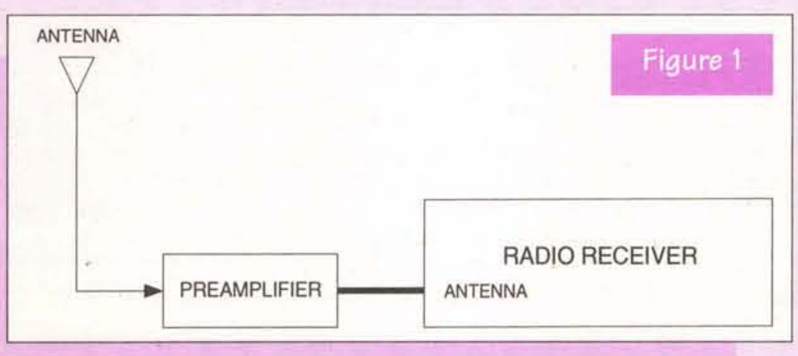
The certificates will be awarded for the distance record will be presented at the FredrichsOhafen Ham Radio event and at the RSGB International HF & IOTA Convention each year.

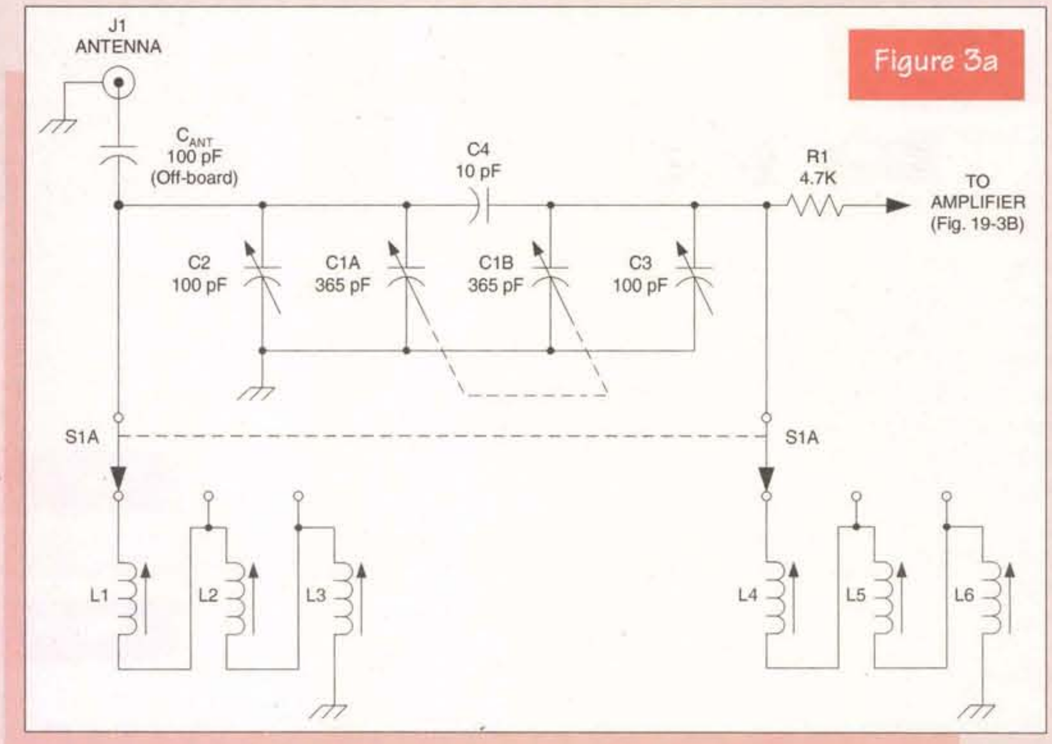
### AMRAD Nags Head (North Carolina) LF Test

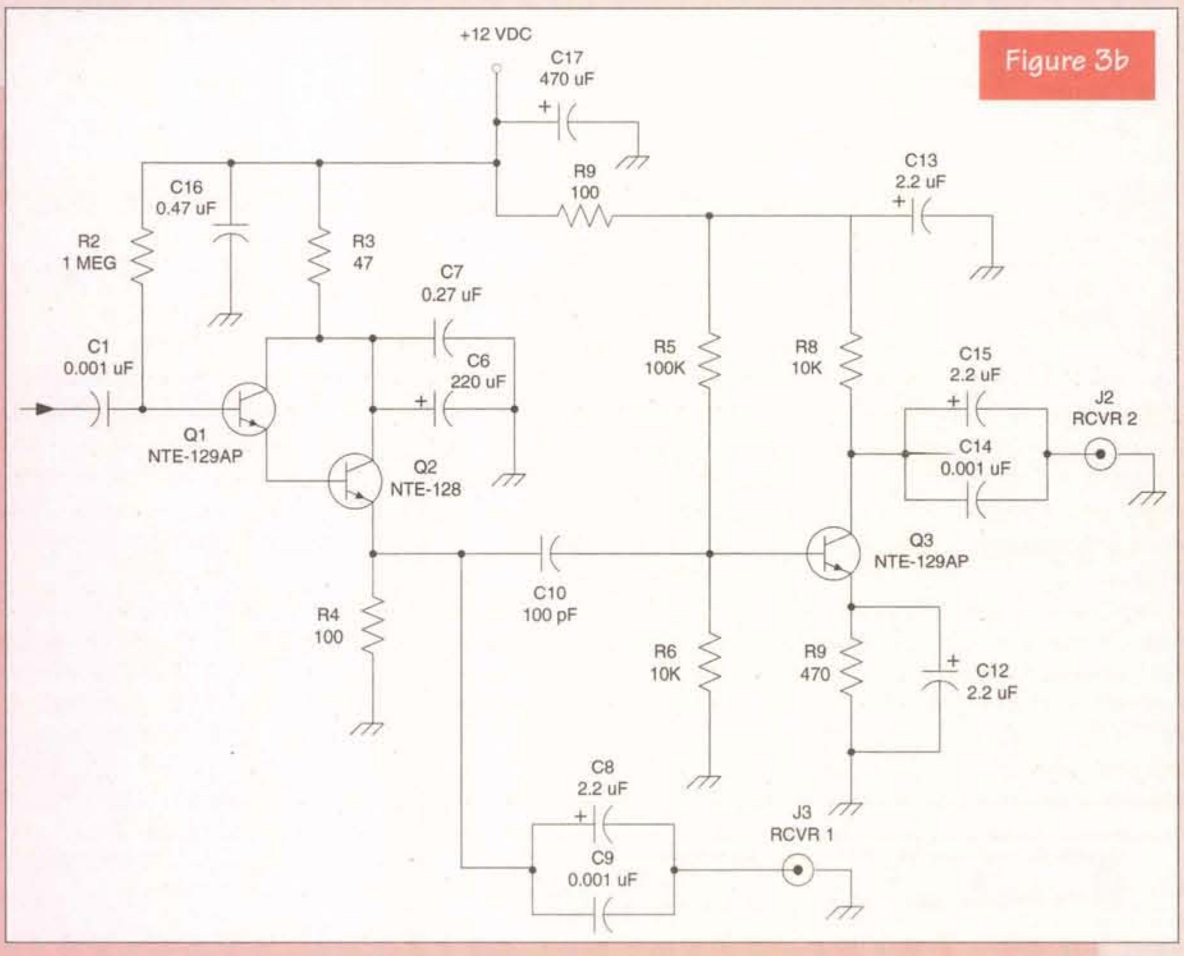
AMRAD members traveled to Nags Head, NC over the January 16, 2000 weekend to try some new and improved equipment on LF bands. The Nags Head site was chosen for a number of reasons. For one thing, it is almost free of the power line noise that afflicts these wavelengths at other locations in the country. Second, European signals arrive across the Atlantic Ocean. Even a short distance over land severely attenuates such signals, so they tend to be down in the mud.

### ELF, VLF, and LF Preamplifiers

There are a number of shortwave receivers on the market that go down to 100 KHz, 50 KHz, or even 25 KHz in one case. The rub is that they tend to be less sensitive on these lower frequencies than they are on






the shortwave bands. In fact, they are considerably less sensitive in the VLF/LF portion of the spectrum than they are on the shortwave bands. Thus, it behooves the radioscience observer to plug in a preamplifier before the circuit to try and get that sensitivity up.

But before we tackle the subject of VLF preamplifiers, let's consider a little bit about preamplifiers in general. Figure 1 shows the placement of a preamplifier or preselector ahead of a radio receiver. The preamplifier is connected in the line between the antenna and the antenna input of the receiver. But it is not as simple as all that ... there are tigers in them thar woods!

The simple fact is that the preamplifier should not deteriorate the receiver's third-order intercept point (TOIP) and dynamic range in order to achieve its benefits. In addition, the Friis noise equation tells us that the preamplifier should have a lower noise figure than the radio receiver. This is because the noise figure of the first stage absolutely dominates the noise performance of the entire system, and the preamplifier becomes the first stage. If the criteria of no deterioration of either TOIP or dynamic range, and low noise, are met, then you are ready for a preamplifier.

## Preamplifiers

Figure 2 shows the circuit for a simple cascade preamplifier consisting of an MPF-102 JFET and a 2N4406 bipolar NPN transistor. The voltage gain is about 3.3 at frequencies of 136 KHz to 250 KHz (the power gain is much larger). For this frequency range, use a 4.7 mH iron core coil for L1, and an NTE-618 varactor for D1 (the NTE-618 is available through replacement parts dealers, and has a capacitance of 440 pF at one volt, and 90 pF at eight volts DC).

Figure 3 shows a three-band VLF preselector and preamplifier for use ahead of a receiver (i.e., between the antenna and the receiver antenna terminals).

The circuit of Figure 3 has two major sections: preselector (Figure 3A) tuning and amplification (Figure 3B). The preselector tuning consists of a dual-section, reactance-coupled parallel L-C tuning network. The main tuning capacitor (C1A, C1B) is a two-section ("dual") AM broadcast variable.

Most of those capacitors are 365 pF per section (be careful, some models have an oscillator section that is less than 365 pF per section ... you want a dual 365 pF unit). Also useful are dual 380 pF, 400 pF, 440 pF, or 500 pF capacitors, all of which I've seen in recent catalogs.

The main tuning capacitor sections are trimmed by small variable capacitors (C2 and C3). For this particular project, I selected the Sprague-Goodman 10-mm type. These capacitors are designed for top adjustment, so are good for cases where the printed circuit board is mounted inside of a cabinet (the recommended approach).

The three inductors in each side of the tuning network (L1/L2/L3 and L4/L5/L6) are switch selected. The switch is a 2P3T rotary switch, i.e., it has two poles and three positions. These are a little hard to find in some stores, but the 3P3T are much easier, and will work well (just ignore the third set of contacts). The inductors are arranged so that in position "A," all three are connected in series; in position "B," two are connected in series; and in position "C," only one coil on each side (L3 and L6) is connected into the circuit. The values for these coils are:

| COIL | VALUE | NUMBER |
|---|---|---|
| L1/L4 | 56 mH | TK-1721 |
| L2/L5 | 56 mH | TK-1721 |
| L3/L6 | 33 mH | TK-1724 |

The two halves of the L-C tuned circuit are coupled by a small mutual reactance. Although either capacitive or inductive reactance can be used for this purpose (although in different ways), the method used in Figure 3 is the capacitive version. Capacitor C4 is used to couple energy from one side of the L-C tank circuit to the other. A 10-pF disk ceramic or silvered mica unit will suffice. The idea is to get as small a value that will couple the two sides without allowing too much interaction. Some people prefer to use a small (<12 pF) variable capacitor in place of C4.

The tuning ranges with the coils shown were measured for the various positions of S1 as follows:

# VLF Radio

| | |
|---|---|
| A | 20.8-36 KHz |
| B | 25.2-44.4 KHz |
| C | 39.1-70.8 KHz |

You can alter the frequency range by selecting different coils from the same series in the Digi-Key catalog, or from some other source (including winding your own, if you are so inclined). Keep in mind that the frequencies are approximate and will differ from the frequencies found from the equation (on your calculator) because of two reasons: First, the inductances have a tolerance associated with them; and second, the inductors have significant capacitance.

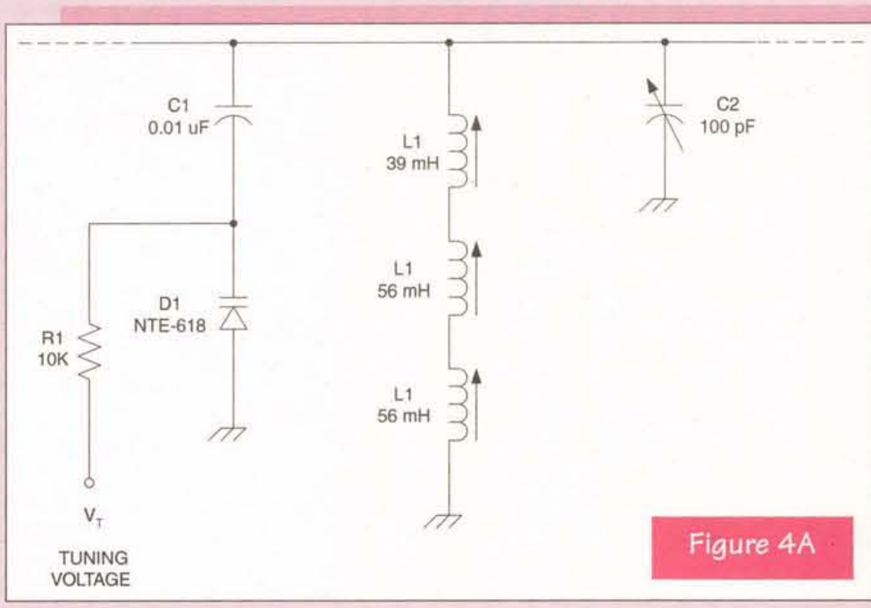



Figure 4A

The values will be within 15 percent or less, but if the frequency that you desire is close to the margin for some particular coil, then be prepared to use a different coil. If you choose to build the circuit for a different set of frequencies, then follow this rule of thumb: the frequency change is proportional to the square root of the inductance change.

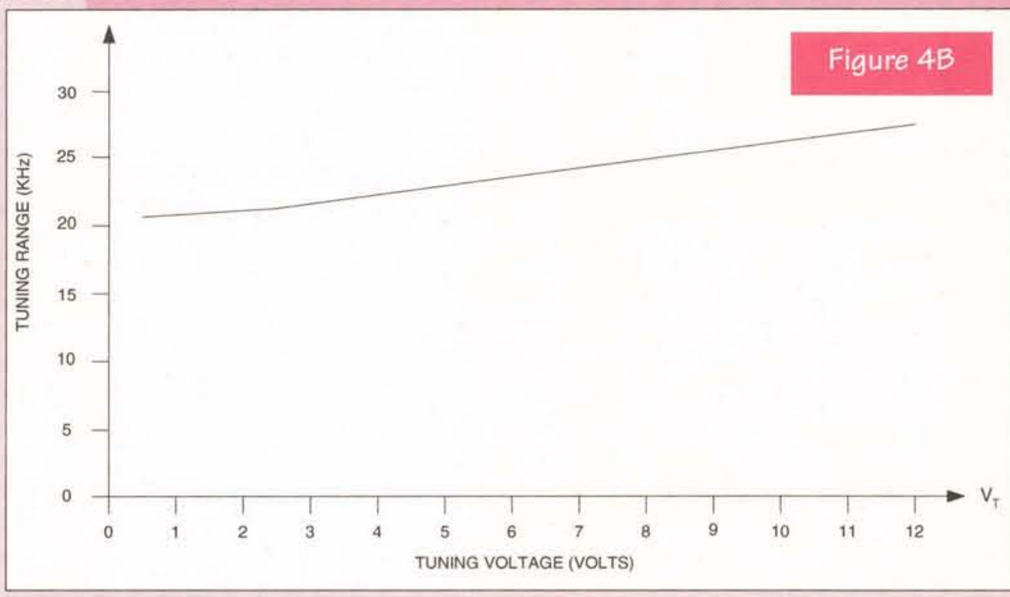



Figure 4B

The signal from the tuned circuit is coupled into a two-stage amplifier (Figure 3B) consisting of three transistors (Q1, Q2, and Q3). Transistors Q1 and Q2 are connected into the Darlington amplifier configuration, so offer a very high input impedance. This stage produces some power gain, but little voltage gain.

If it were a common emitter circuit, rather than a common collector circuit, the gain would be huge (i.e., the product of the betas of Q1 and Q2). Because Q1/Q2 is an emitter follower (common collector) amplifier, the signal is taken from the emitter of Q2 and fed to two destinations: a low gain output (OUT1) and the input of the final amplifier stage (Q1).

The circuit of Q1 is a common emitter amplifier. It uses the standard voltage divider form of biasing, with an emitter resistor to stabilize the circuit. The output of this amplifier is taken from the collector, and fed to the high gain output (OUT2).

The transistors selected for this project are the NTE-128 and NTE-129AP (also, the ECG-128 and ECG-129AP will work, as well). These parts are available from many parts distributors. Neither transistor is particularly critical, however. Q1 and Q2 were replaced with 2N4401 in one version, and worked the same as the selected transistors. Transistor Q2 can be any "audio output/video driver" NPN silicon device with a gain-bandwidth product of 100 MHz, and a beta gain around 90.

The power distribution network takes the +12 VDC power supply, and sends it to the two stages. In both stages, there is a small value resistor (R3 and R9) used to improve decoupling between stages. The actual decoupling is performed by capacitor pairs C6/C7, C11/C13, and C16/C17. In each case, a pair of capacitors – one low value and one a high value electrolytic – is used.

The high value capacitors are used to smooth power supply variations and reduce any power supply noise, as well as decoupling low frequency feedback through the DC

power supply. The low value capacitors are used for high frequency decoupling.

Alignment of the circuit is relatively straightforward, although it requires a signal generator. The signal generator could be an RF generator that goes down to 10 KHz (a few exist), or an audio generator, or function generator that has a low impedance sinewave output (50 ohms or 600 ohms) ... which is about all of them.

Alignment begins with the tuning capacitor (C1) fully meshed, the bandswitch set to position "D," and either an AC voltmeter or oscilloscope monitoring the amplified output (OUT2). Alternatively, connect the preselector to the receiver and find the minimum frequency point on its dial.

Adjust the signal generator frequency until a peak is found. In all likelihood, the first cut will show a "double humped" tuning characteristic because the two halves of the L-C network are not adjusted to the same frequency. Adjust L3 and L6 for a peak response. Next, adjust C2 and C3 for a peak response. These adjustments are interactive, so do it two or three additional times to make sure that the actual peaks are reached.

Next, set the tuning capacitor fully open (all the way unmeshed). Find the peak frequency by adjusting the signal generator. For this adjustment, leave the inductors alone and just peak C2 and C3.

Next, align band "B" in the same manner, except that the capacitors are not trimmed. That means you adjust L2/L5 only. Finally, adjust band "A" by following the same procedure for L1/L4.

## Variation on the Theme

There are two variations on the circuit that may interest some readers. First, is varactor tuning for those who can't find the dual tuning capacitors, or don't want to use the capacitor. In this circuit (Figure 4A), an AM BCB varactor (voltage variable capacitance) diode is used to replace the capacitor.

The varactor selected is the NTE-618, which has a capacitance of a few pF up to 440 pF, as the applied reverse bias tuning voltage VT is changed from 12 VDC down to 1.00 VDC. Capacitor C1 is used to provide DC blocking that keeps the tuning voltage (VT) from affecting (or being affected by) the inductors and following circuitry.

The tuning characteristic for the VLF preamplifier, found during a bench test, is shown graphed in Figure 4B. With this combination, the tuning ranged from 20.5 to 28.5 KHz when the trimmer was set to 45 pF and the inductances were set to 116.5 mH.

## Reducing AM BCB Interference on VLF

The AM broadcast band covers 540 to 1,700 KHz, while the LF and VLF frequencies are those frequencies below 540 KHz. Therefore, one should not expect interference from local AM broadcast stations while noodling around in the "down unda" bands, right? No, not by a long shot. There are two basic reasons.

First, the AM stations may tend to be very local. Second, radio stations tend to be high powered. One location where I lived was known locally as "Intermod Hill" because there were a large number of radio transmitters up there, including two FM BCB (50 kw each) stations and one 5,000 watt AM BCB station. Living just a few blocks from that 5,000-watt gigablaster tore a hole in every receiver I owned. With such strong field strengths, almost all receivers overloaded.

Incidentally, the way I graded receivers in those days was how free they were from such interference. And it wasn't always the most expensive model that was the most free of problems.

A way to solve the problem is to use a low-pass filter (LPF) ahead of the receiver that has a cut-off frequency somewhere below 540 KHz. Figure 5 shows a seven-element LPF with a 0.1 dB ripple factor, designed for 50-ohm input and output impedances. The LPF consists of four inductances (L1-L4) and three capacitors (C1-C3). Each capacitor is made up of two parallel capacitances in order to obtain the correct capacitance.

Those capacitors should be a relatively stable, five percent tolerance, type such as the Panasonic B-Series polyester or V-Series metallized film capacitors. For receive-only applications, the voltage rating is not an issue, so 50-WVDC capacitors in those series will work nicely.

The inductance values shown in Figure 5 are for the VLF version of the tuner, for which a 120 KHz -3 dB cut-off frequency is specified. The 75-mH inductors are Toko TK-4256, while the 130-mH inductors are Toko TK-4262. If you want to make the LPF work for a different cut-off frequency, then consult Table 1 for component values:

The layout of the LPF circuit should follow "good low frequency RF practices," which means that you want at least a small separation between the inductors. Construction on perforated board is quite satisfactory. My initial version was built "rat's nest" style on printed circuit perf-board. That form has printed circuit connection points on a 0.1 X 0.1 inch pattern, so is easy to solder to and use.

By the way, the same circuit can be used for any frequency. This LPF is somewhat universal. To find the values of the components, use the following formulas: L1 = L4 = 9.4/FMHz; L2 = L3 = 16.68/FMHz; C1 = C3 = 4538.9/FMHz; and C2 = 5008.3/FMHz, where FMHz is the frequency in MegaHertz. The coils can be made from T-37-xx toroidal cores, or selected from the Toko coils. Select fixed coils with a 5 mm (0.2 inch) pin spacing ... which is nearly all of them in that catalog. **NV**

**TABLE I**

| BAND | L1/L4 | L2/L3 | C1 | C2 | C3 |
|---|---|---|---|---|---|
| <300 KHz | 33 mH | 56 mH | 0.015 mF | 0.0167 mF | 0.015 mF |
| <500 KHz | 18 mH | 33 mH | 0.009 mF | 0.01 mF | 0.009 mF |

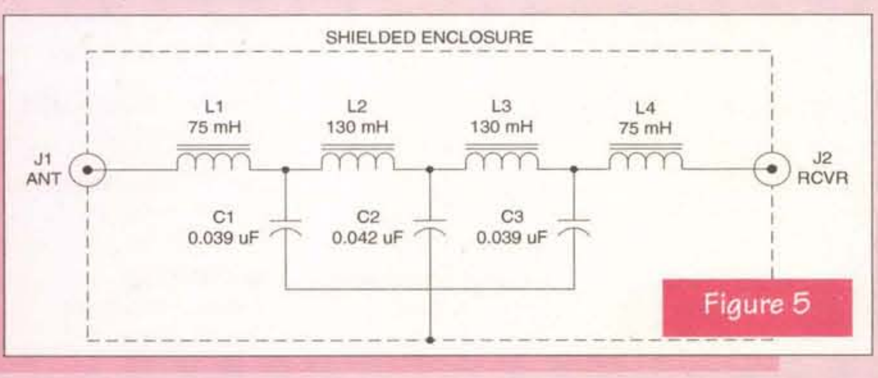



Figure 5

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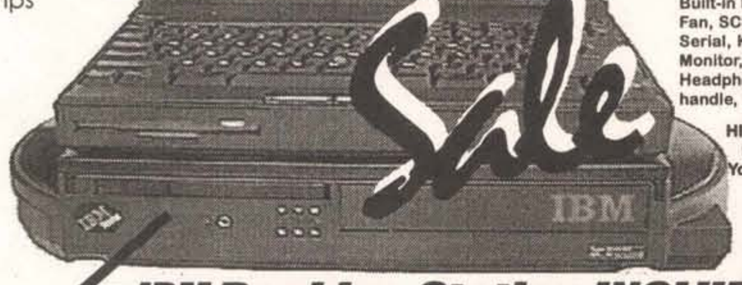


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# Power Supply Design Software

by Ken Coffman

Power supplies are not that difficult to design, but keeping track of all the details can be a real chore. At least the elementals are constant: power, voltage, current, magnetics, capacitors, etc. Devices may change, but the physics of power design do not. Once you've mastered the basics, you have some skills that won't be obsolete next year like a lot of other engineering skills.

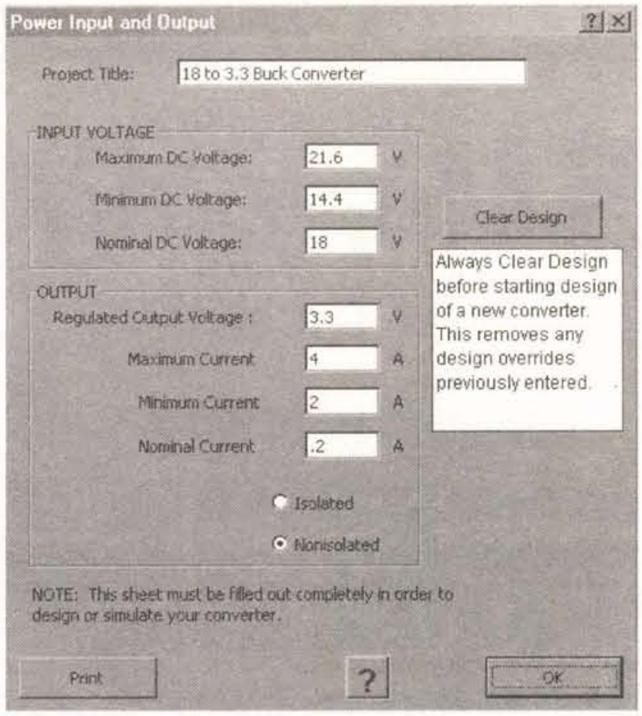


**Figure 2** Power Input and Output Specification

## Buck Regulator Design

The most common power supply topology is the buck converter. Basically, an input voltage is chopped by a switch and filtered. Right away we sense the advantage of the switched-mode power supply; the switches are either on or off and therefore dissipating little energy (we'll ignore switching losses for now). Energy is stored in a series inductor; it charges and discharges around an operating point that supports a regulated load voltage.

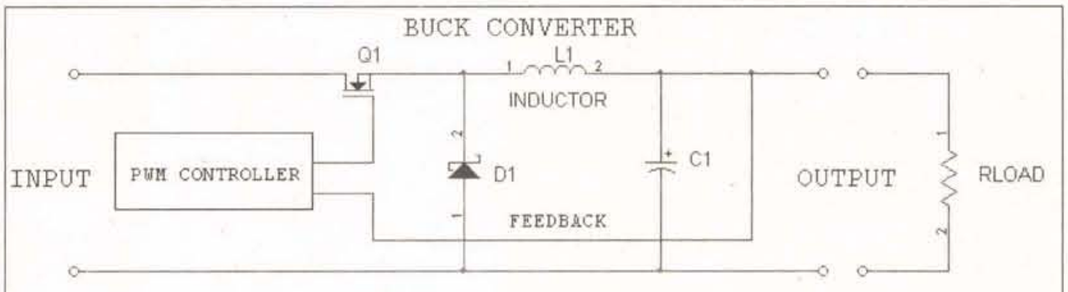


**Figure 1** Buck Regulator Schematic

Taking a look at Figure 1, a couple of things jump out. First of all, there is no isolation, the input ground is connected to the output ground. Second of all, if the switch (Q1) is always on, the output will be equal to the input, this is the absolute maximum output voltage that could be achieved. Practically, the output must be less than the input. The circuit operates in two modes:

- With Q1 on, D1 is off, and L1 is charging.
- With Q1 off, D1 is conducting, and L1 is discharging.

The best way to visualize circuit operation is to remember that an inductor resists a changing current; with a current flowing through L1 and into the load, when Q1 turns off, the current will continue to flow and the only possible path for current to be sourced is through D1. The output is proportional to the input voltage and the duty cycle of Q1's conduction.

The trickiest part of a buck regulator design is transfer function; we need to assure that the output is stable for all input and load conditions. If the load or input voltage changes, we prefer the output move smoothly to the new operating point without overshoot.

We also want the output to change fast enough to avoid significant voltage droop. If it appears these requirements are contradictory, that's because they are.

## Power Supply Design Software: Power456 plus

Fortunately, a software tool exists which can help us keep track of all the details of a switched-mode power supply design and help us design the compensation to keep our power supply stable. This software is called Power456 plus and is available from Ridley Engineering (see contact information elsewhere in this article). Power456 is a group of applications based on the Microsoft Excel spreadsheet.

To get started, we invoke Power456 and press the START button. Then we select the Enter Power Specifications button and we see the screen shown in Figure 2.

For this example, I defined a 3.3V 6.6W power supply with an 18V ±20% input. Press OK and a menu with a complete selection of power supply topologies appears (see Figure 3). We're studying the buck topology, so we'll click on the Buck selection. A top-level view of the design pops up, (see Figure 4).

All of a sudden our simple buck converter looks more intimidating, but don't panic yet. All the elements of Figure 1 are in this block diagram with

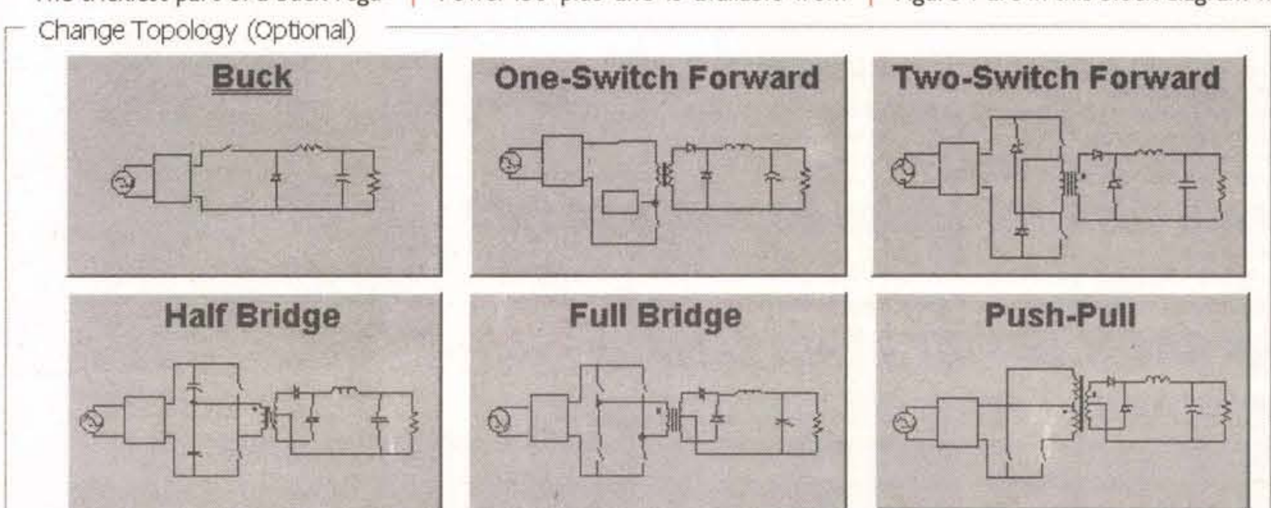


**Figure 3** Power Supply Topology Selection

# Power Supply Design Software

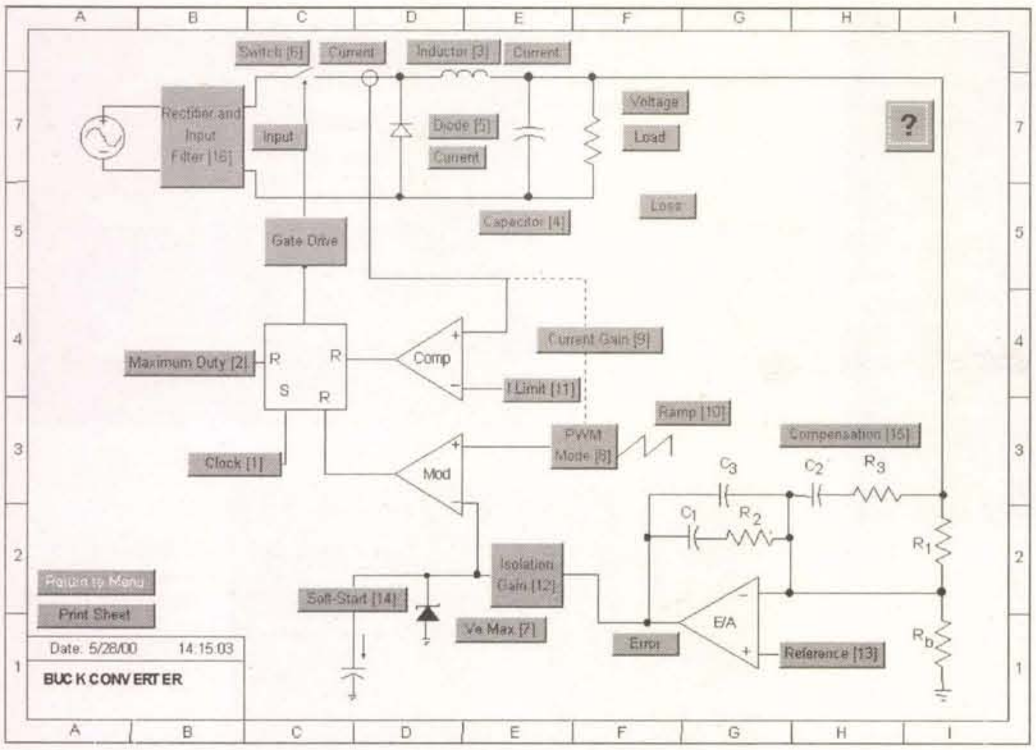


**Figure 4** Buck Regulator Block Diagram

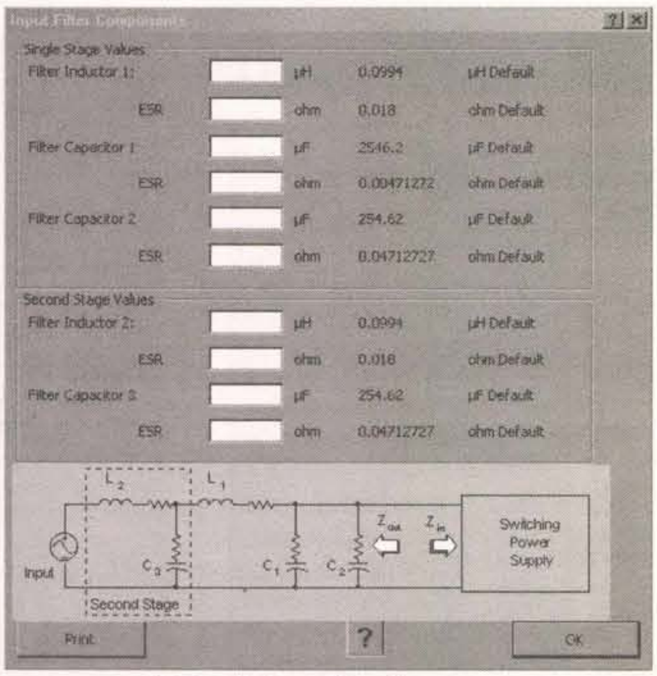


**Figure 5** Input Filter Components

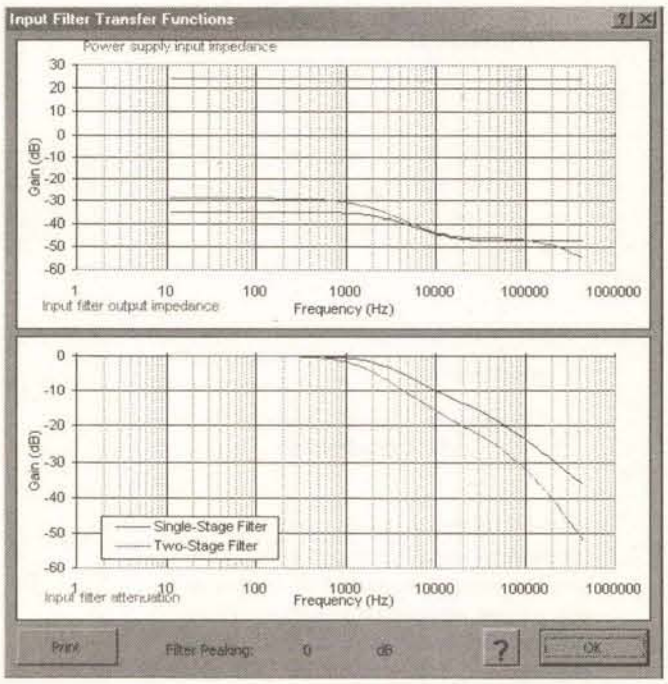


**Figure 6** Input Filter Impedance/Attenuation Plots

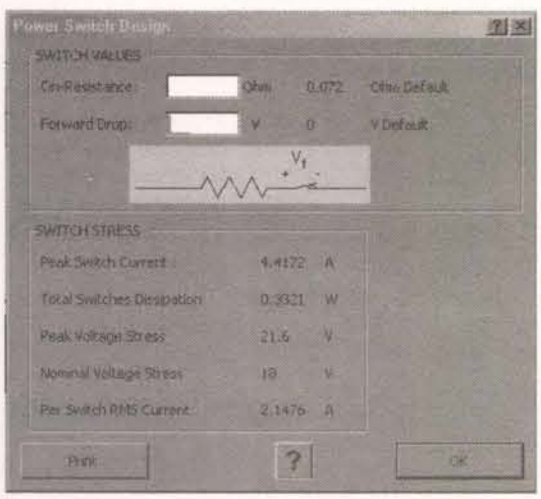


**Figure 7** Transistor Switch Stresses

details of the input filter, the PWM controller and the compensation circuit expanded.

Don't you hate it when an application note leaves out essential parts of a real-world design? Power456 will keep you out of trouble by including all the sections of a complete design. This is a good thing! If you click on the input filter block, the Input Filter Component screen is displayed (see Figure 5).

You will note that Power456 has filled in default (nominal) values for capacitor and inductor characteristics; enter in the real values for the components you choose and the analysis will reflect these parameters. The only things missing are the transient voltage suppressors and fuses necessary for operating in offline applications. The characteristics of these devices will not affect the circuit analysis.

Figure 6 shows the transfer function (filter output impedance vs. frequency and attenuation vs. frequency plots) of the input filter. Figure 7 summarizes the transistor switch stresses. MOSFETs are modeled with on-resistance only (as shown with forward drop set to zero); bipolar transistors are modeled with both on resistance (to reflect bulk resistance of the device) and forward drop (to reflect $V_{ce(sat)}$).

It may not seem natural to think of the diode as a switch, but that's the way it acts in the buck converter circuit. Like the bipolar transistor, as shown in Figure 8, the diode is modeled as a forward drop and bulk resistance (the forward resistance is small for a power diode, so the default value is 0; fill in the more correct value from the diode data sheet, as necessary).

Figure 9 shows the current plots for the diode and transistor switch. When the switch turns on, it quickly sources current to charge the inductor flux. When the transistor is off, the inductor begins discharging with the diode closing the loop.

The power supply designer must choose the desired control mode. There are two traditional modes of


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E-mail: kcoffman@nuhorizons.com
www.bytechservices.com
www.nuhorizons.com



Thanks to Craig Ranta who made some constructive suggestions for this article.



References and recommended reading:
Ridley Engineering Power456 Help files
*Feedback Loop Stability Analysis*, Walter S. Friauf, published by McGraw-Hill, 1998

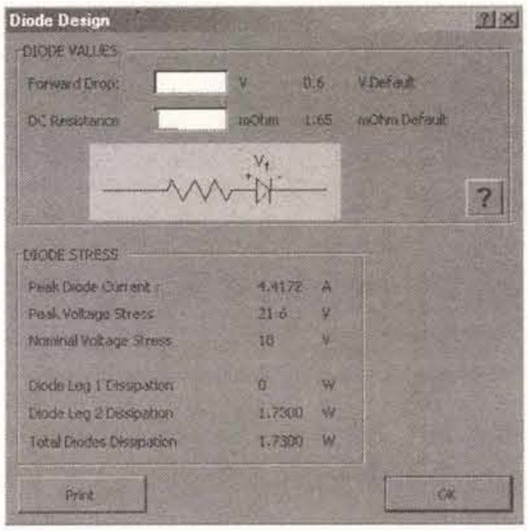


**Figure 8** Diode Stress Summary

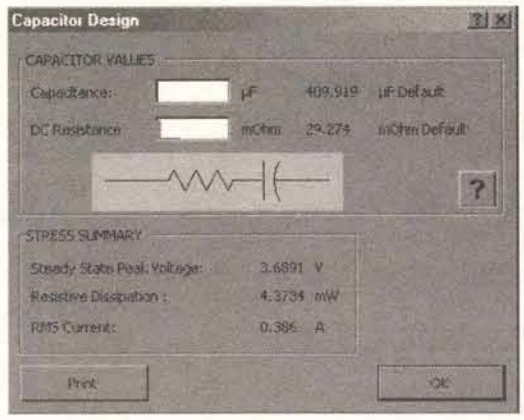


**Figure 10** Output Capacitor Characteristics

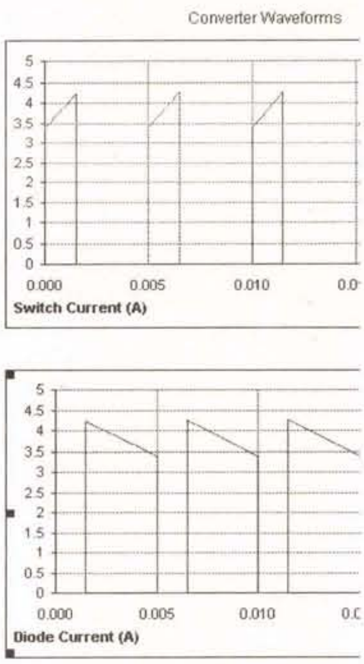


**Figure 9** Diode/Transistor Current Waveforms

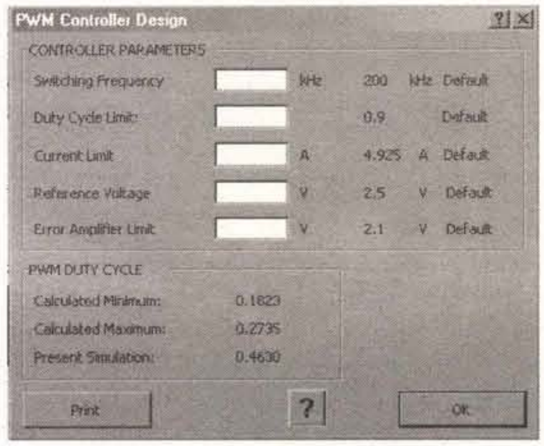


**Figure 11** Pulse Width Modulator (PWM) Controller Characteristics

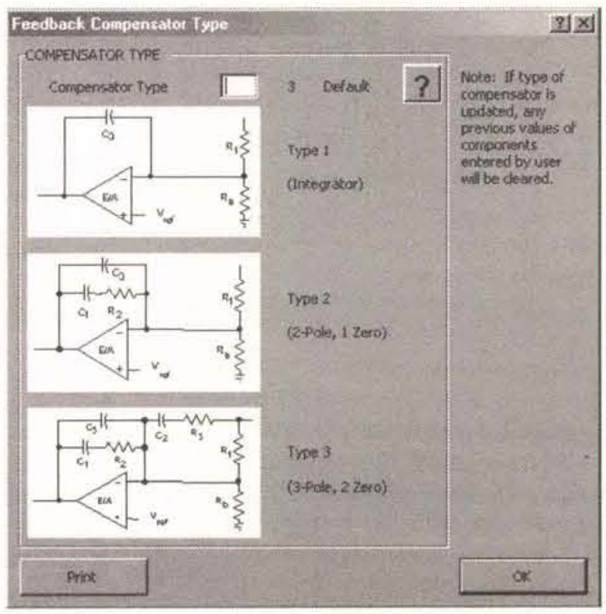


**Figure 12** Feedback Compensation Types

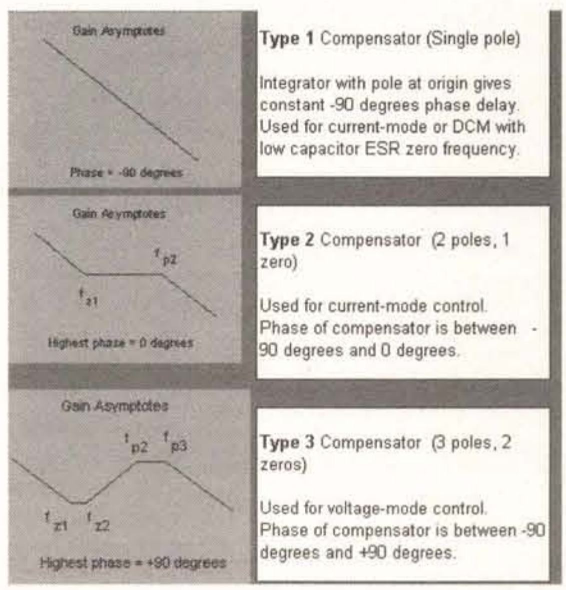


**Figure 13** Feedback Compensation Types Help Screen

control: voltage mode and current mode. A voltage-mode controller samples the output voltage and compares the voltage sample to the PWM ramp voltage. When the output is less than the ramp, Q1 is turned on and vice versa. This gives proportional control; the greater the difference between the ramp and the output, the longer period that the power switch is turned on.

Current-mode control sums the switch current with a compensating ramp signal and compares this to an error voltage (proportional to the difference between the output voltage and the reference voltage). A built-in advantage of this control mode is the inherent cycle-by-cycle current limit which protects the transistor.

Ridley Engineering recommends current mode control for all switched-mode power supply topologies, except the half bridge. Figure 10 summarizes the characteristics of the output filter capacitor (C1). Figure 11 shows the controller parameters including the reference voltage; these values can be filled in to reflect the characteristics of the selected power supply controller.

## Feedback Compensation Design

Power456 supports three types of compensation networks as shown in Figure 12. The simplest is called Type 1 (one pole), an integrator circuit which allows the output to slew to operating points at a fixed rate. Type 2 compensation adds a pole/zero network to speed up the slew rate at lower frequencies with rapid attenuation at higher frequencies to assure stability. Type 3 adds yet another pole/zero pair. Each screen has a handy help button (?) which brings up background

Power Supply Design Software

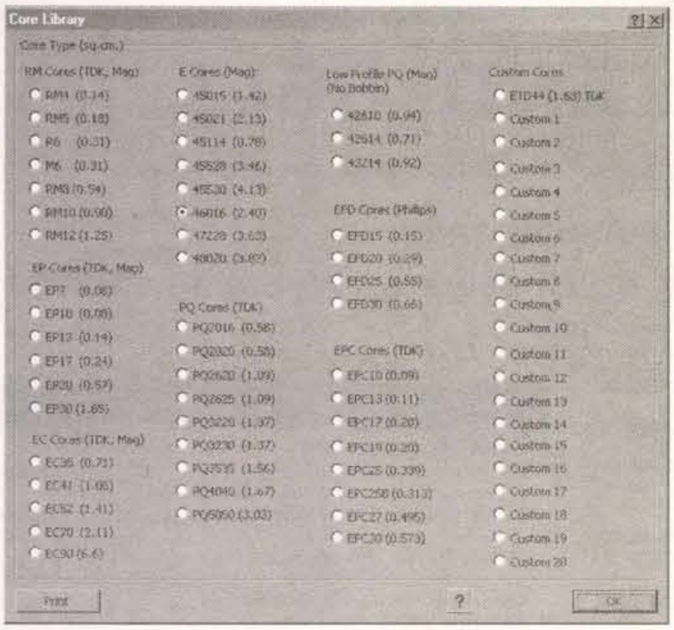


**Figure 18** Core Library

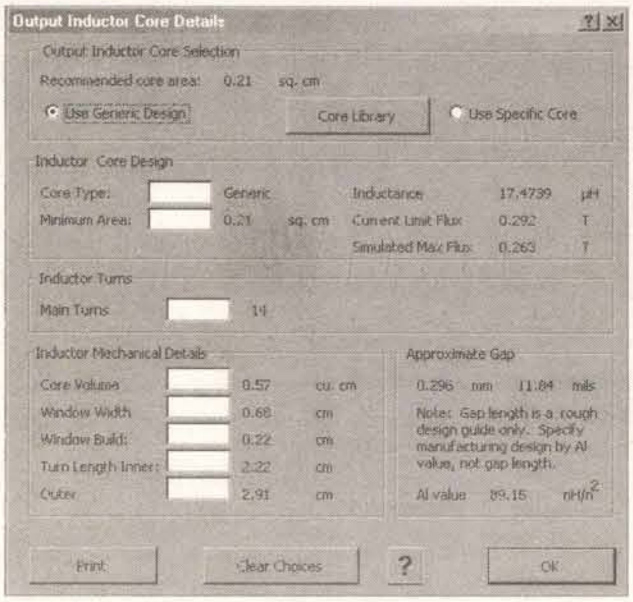


**Figure 16** Output Inductor Core Details

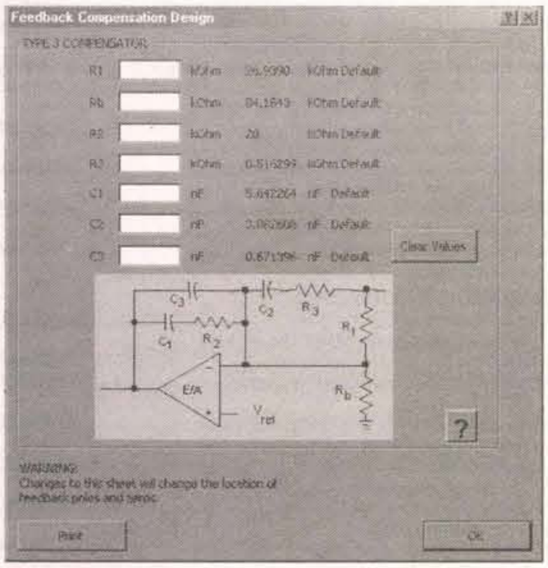


**Figure 14** Feedback Compensation Design

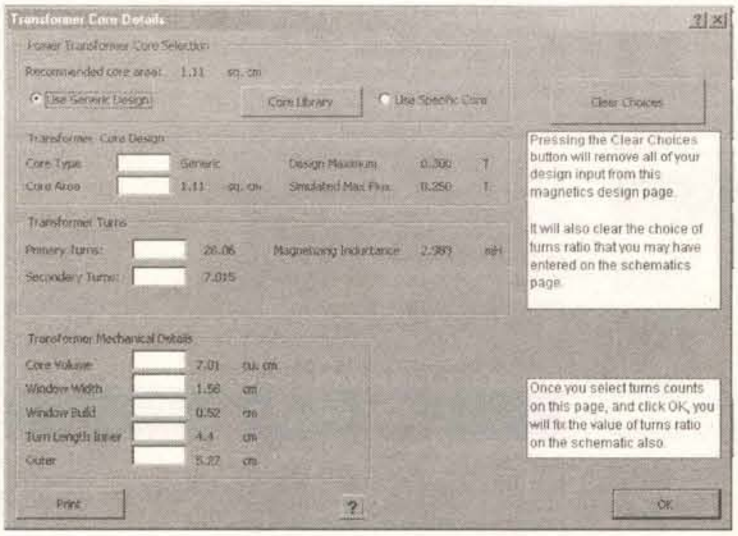


**Figure 17** Transformer Core Details

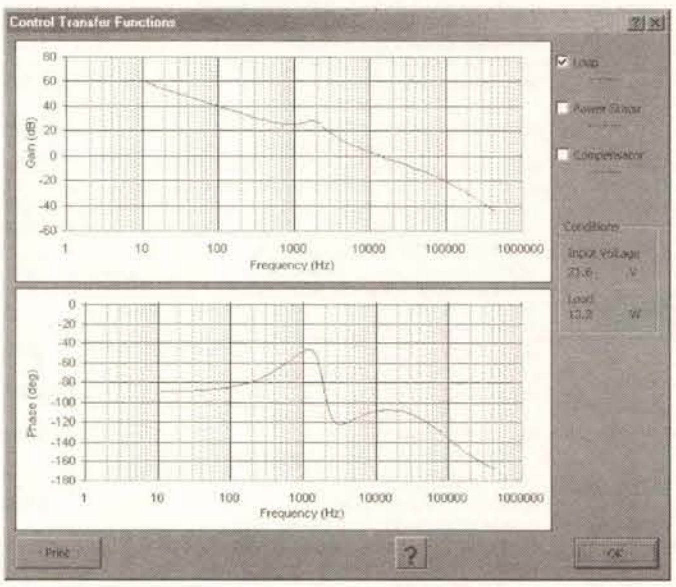


**Figure 15** Feedback Network Bode (Gain/Phase) Plots

information. The help screen for the Feedback Compensation Type is shown in Figure 13.

The compensation network component values are entered in the Feedback Compensation Design sheet as shown in Figure 14. The resulting Bode (gain/phase) plots for Type 3 feedback networks are shown in Figure 15.

The basic rule for network stability is to assure that phase margin exists at all frequencies. Phase margin means that negative feedback (-180 degrees) is assured.

To achieve this, when the network phase reaches somewhere around -90 (for a total of about -270 degrees when 180 degrees for the inverting amplifier is included), the gain should be zero or negative.

What you absolutely do not want is positive gain when the total phase approaches 360 degrees; this is positive feedback and is the very definition of instability. Remember that the inverting op amp circuit in the feedback circuit contributes -180 of phase and the RC feedback network contributes additional negative phase depending on the feedback component values and the frequency in question.

Usually, for a typical buck regulator design, the inductor is purchased off-the-shelf. However, to support the design of the inductor (and the design of magnetics for more specialized designs), an inductor core design sheet is provided. Figure 16 shows an example. The physical and electrical properties of the inductor are entered and the inductor values are used in the analysis of circuit operation (losses, etc.).

Power456 can also be used to design transformers for other power supply topologies (including an isolated buck topology). Figure 17 illustrates the transformer design sheet. Power456 includes a core library with common commercially-available core styles and materials, other cores can be entered to customize this library.

As far as I know, the Ridley Engineering power supply design tool is unique in its completeness, low cost, and ease of use. The list price of $995.00 will more than pay for itself when the first reliable and well-documented power supply design is achieved with its help. **NV**

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HP 33321K Programmable Step Atten., ... $475.00
0-70 dB, DC-26.5 GHz, 3.5mm
HP 33327L-006 Programmable ... $1,000.00
Step Attenuator, 0-70 dB, DC-40 GHz, 2.9mm
HP 774D Dual Directional Coupler, 20 dB, 215-450 MHz ... $275.00
HP 776D Dual Directional Coupler, 20 dB, 940-1900 MHz ... $275.00
HP 777D Dual Directional Coupler, 20 dB, 1.9-4.1 GHz ... $275.00
HP 778D-011 Dual Dir. Coupler, 20 dB, ... $450.00
100-2000 MHz, APC7 test port
HP 8431A 2-4 GHz Band Pass Filter, N(m/f) ... $150.00
HP 8494G-002 Programmable ... $350.00
Step Attenuator, 0-11 dB, DC-4 GHz, SMA
HP 8496A-002 Step Attenuator, 0-110 dB, DC-4 GHz, SMA ... $375.00
HP 8497K-004 Programmable Step ... $750.00
Attenuator, 0-90 dB, DC-26.5 GHz
HP K422A WR42 Flat Broadband Detector, 18.0-26.5 GHz ... $350.00
HP K532A WR42 Frequency Meter, 18.0-26.5 GHz ... $450.00
HP K752D WR42 Directional Coupler, 20 dB, 18.0-26.5 GHz ... $450.00
HP K870A WR42 Slide Screw Tuner, 18.0-26.5 GHz ... $275.00
HP K914B WR42 Moving Load, 18.0-26.5 GHz ... $300.00
HP Q752D WR22 Directional Coupler, 20 dB, 33-50 GHz ... $650.00
HP R382A WR28 Direct Reading ... $2,250.00
Attenuator, 0-50 dB, 26.5-40 GHz
HP R422A WR28 Crystal Detector, 26.5-40 GHz ... $400.00
HP R752D WR28 Directional Coupler, 20 dB, 26.5-40 GHz ... $450.00
HP R914B WR28 Moving Load, 26.5-40 GHz ... $250.00
HP V365A WR15 Isolator, 25 dB, 50-75 GHz ... $750.00
HP V752D WR15 Directional Coupler, 20 dB, 50-75 GHz ... $650.00
HP X870A WR90 Slide Screw Tuner ... $150.00
HUGHES 45322H-1110/1120 WR22 ... $350.00
Directional Couplers, 10 or 20 dB, 33-50 GHz
HUGHES 45712H-1000 WR22 Frequency Meter, 33-50 GHz ... $750.00
HUGHES 45714H-1000 WR15 Frequency Meter, 50-75 GHz ... $900.00
HUGHES 45721H-2000 WR28 Direct ... $1,000.00
Reading Attenuator, 0-50 dB, 26.5-40 GHz
HUGHES 45722H-1000 WR22 Direct ... $1,000.00
Reading Attenuator, 0-50 dB, 33-50 GHz
HUGHES 45724H-1000 WR15 Direct ... $1,000.00
Reading Attenuator, 0-50 dB, 50-75 GHz
HUGHES 45732H-1200 WR22 Level Set ... $250.00
Attenuator, 0-25 dB, 33-50 GHz
HUGHES 45752H-1000 WR22 Direct ... $1,400.00
Reading Phase Shifter, 0-360 deg.,33-50 GHz
HUGHES 45772H-1100 WR22 ... $400.00
Thermistor Mount, -20 to +10 dBm, 33-50 GHz
HUGHES 45773H-1100 WR19 ... $650.00
Thermistor Mount, -20 to +10 dBm, 40-60 GHz
HUGHES 45774H-1100 WR15 ... $750.00
Thermistor Mount, -20 to +10 dBm, 50-75 GHz
HUGHES 47316H-1111 WR10 ... $600.00
Tuneable Detector, 75-110 GHz, positive polarity
HUGHES 47741H-2310 WR28 ... $2,000.00
Phase Locked Gunn Osc., 32.000 GHz, +18 dBm
HUGHES 47742H-1210 WR22 ... $2,750.00
Phase Locked Gunn Osc., 42.000 GHz, +18 dBm
KRYTAR 201020010 Directional ... $200.00
Detector, 1-20 GHz, SMA(f/f)/SMC
KRYTAR 2616S Directional Detector, ... $200.00
1.7-26.5 GHz, K(f/m)/SMC
M/A-COM 3-19-300/10 WR19 ... $450.00
Directional Coupler, 10 dB, 40-60 GHz
MICA C-121S06 Circulator, 17.5-24.5 GHz, SMA(f/m/m) ... $75.00
MINI-CIRCUITS ZFDC-20-4 ... $25.00
Directional Coupler, 19.5 dB, 1-1000 MHz, SMA(f)
NARDA 3000-SERIES Directional Couplers ... $150.00
NARDA 3020A Bi-Directional Coupler, 50-1000 MHz, N ... $475.00
NARDA 3024 Bi-Directional Coupler, 20 dB, 4-8 GHz ... $375.00
NARDA 3090-SERIES Precision High Directivity Couplers ... $225.00
NARDA 368BNM Coaxial High Power ... $500.00
Load, 500 Watts, 2.0-18 GHz, N(m)
NARDA 3752 Coaxial Phase Shifter, ... $1,000.00
0-180 deg./GHz, 1-5 GHz
NARDA 3753B Coaxial Phase Shifter, ... $1,000.00
0-55 deg./GHz, 3.5-12.4 GHz
NARDA 4000-SERIES SMA Miniature Directional Couplers ... $75.00
NARDA 4226-10 Directional Coupler, ... $275.00
10 dB, 0.5-18.0 GHz, SMA(f)
NARDA 4227-16 Directional Coupler, ... $325.00
16 dB, 1.7-26.5 GHz, 3.5mm(f)
NARDA 4242-20 Directional Coupler, ... $100.00
20 dB, 0.5-2.0 GHz, SMA(f)
NARDA 4247-20 Directional Coupler, ... $200.00
20 dB, 6.0-26.5 GHz, 3.5mm(f)
NARDA 4247B-10 Directional Coupler, ... $200.00
10 dB, 6.0-26.5 GHz, 3.5mm(f)
NARDA 5070-SERIES Precision Reflectometer Couplers ... $300.00
NARDA 562 DC Block, ... $65.00
10 MHz-12.4 GHz, 100 V max., N(m/f)
NARDA 765-10 10 dB Attenuator, ... $165.00
50 Watts, DC-5 GHz, N(m/f)
NARDA 791FM Variable Attenuator, 0-37 dB, 2.0-12.4 GHz ... $600.00
NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz ... $375.00
NARDA 794FM Direct Reading Variable ... $375.00
Attenuator, 0-40 dB, 4-8 GHz
OMNI-SPECTRA 2085-6010-00 ... $50.00
Crystal Detector, 1-18 GHz, negative polarity, SMA(m/f)
PAMTECH KYG1014 WR42 ... $250.00
Junction Circulator, 18.0-26.5 GHz
SONOMA SCIENTIFIC 21A3 WR42 ... $75.00
Circulator, 20 dB, 20.6-24.8 GHz
TEKTRONIX 2701 Step Attenuator, ... $175.00
0-79 dB, DC-1 GHz, AC or DC coupled
TRG B510 WR22 Direct Reading ... $900.00
Attenuator, 0-50 dB, 33-50 GHz
TRG V510 WR15 Direct Reading ... $900.00
Attenuator, 0-50 dB, 50-75 GHz
TRG V551 WR15 Frequency Meter, 50-75 GHz ... $600.00
TRG W510 WR10 Direct Reading ... $1,000.00
Attenuator, 0-50 dB, 75-110 GHz
TRG W551 WR10 Frequency Meter, 75-110 GHz ... $750.00
WAVELINE 100080 WR28 Terminated ... $200.00
Crossguide Coupler, 30 dB
WEINSCHEL 150-110 Programmable S ... $450.00
tep Attenuator, 0-110 dB, DC-18 GHz, SMA
WEINSCHEL DS109 Double Stub Tuner, 1-13 GHz, N(m/f) ... $150.00
WEINSCHEL DS109LL Double Stub ... $150.00
Tuner, 0.2-2.0 GHz, N(m/f)

## COMMUNICATIONS

HP 3780A Pattern Generator / Error Detector, 1 kb/s - 50 Mb/s ... $850.00
HP 4935A Transmission Impairment Measuring Set ... $600.00
HP 59401A HPIB Bus Analyzer ... $375.00
MICRODYNE 1200MR 215-320 MHz ... $450.00
Telemetry Receiver, PSK demodulation
TEK 1410R NTSC Gen., ... $800.00
w/SPG2 sync. generator, TSG7 color bars
TEK 1411R PAL Gen.,w/SPG12 sync; ... $750.00
TSG11 color bars;TSG13 linearity
TEK 1411R PAL Test Gen., ... $1,000.00
w/SPG12,TSG11,TSG13,TSG15,TSG16
TEK 1411R PAL Test Gen., ... $1,100.00
w/SPG12,TSG11,TSG12,TSG13,TSG15,TSG16
TEK 1411R-opt.04 PAL Test Gen.,w/
SPG12,TSG11,TSP11,TSG13,TSG15,TSG16 ... $1,400.00
TEK 147A NTSC Test Signal Generator, ... $800.00
with noise test signal
TEK 148 PAL Insertion Test Signal Generator ... $700.00
TEK 520A NTSC Vectorscope ... $750.00
TEK 521A PAL Vectorscope ... $750.00

## MISCELLANEOUS

EG&G / P.A.R. 5302 / 5316 Lock-in ... $2,250.00
Amplifier, 100 mHz-1 MHz, GPIB / RS232C
FLUKE 2180A RTD Digital Thermometer ... $500.00
P.A.R. 5206-95,98 Two-Phase ... $1,500.00
Lock-in Amp., 2 Hz-100 kHz, GPIB
TEK TM5006 5000-series 6-slot ... $500.00
Programmable Power Module
TEK TM504 500-series 4-slot Power Module ... $175.00
TEK TM506 500-series 6-slot Power Module ... $250.00
TEK TM515 500-series 5-slot Traveller Power Module ... $250.00

Write in 171 on Reader Service Card.

# ELECTRONICS Q&A

*With TJ Byers*

*In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist. Feel free to participate with your questions, as well as comments and suggestions. You can reach me at:* ***TJBYERS@aol.com*** *or by snail mail at Nuts & Volts Magazine, 430 Princeland Ct., Corona, CA 92879.*

## What's Up:

Need to fix a bunch of monitors or power supplies? Not a problem, it's probably a common component. Capactive ESR revisited, and a nudge about vacume tubes. More to come on valves next month. Finally, Mars as art — 25,000 photos on the web as eye candy.

### Shrinking PC Monitor

**Q.** I have acquired several late model 15-inch super VGA monitors recently, and many of them exhibit a common problem. The picture is usually pulled in at the sides, and sometimes at the top and bottom as well. These monitors use software pots for adjustments, but I believe the problem is deeper than that. Usually a capacitor in the horizontal or vertical circuitry is the culprit, but without a schematic, I have little to go by. Do you know of a source of published information that is available without having to be a retailer or dealer?

**Dave Frechette**
**via Internet**

**A.** Schematics for PC monitors are available from Sams Photofact (**1-800-428-7267; www.hwsams.com**). If your particular model isn't listed in their catalog, use a schematic from a model of the same screen size and same manufacturer. While the PCB layout may not be the same, the electronics should be nearly identical (e.g., similar schematics).

From the symptoms you describe, I can make a good guess as to what the problem is. You're right, it's a capacitor — but not in the horizontal or vertical circuits. The culprit is an open capacitor in the low-voltage power supply. You see, there are several capacitors in the main power supply section, so if one goes open it doesn't shut down the monitor. Instead, it lowers the output voltage which results in lower HV and a smaller image all around. For this fix, you don't need a schematic. Simply locate the low-voltage filter caps (probably a few hundred uF rated at 180 volts) and bridge a good capacitor of similar value across each in succession until the screen expands to full size. That will be the defective cap. After a few monitors, you'll probably notice a pattern, in that the same capacitor will be the defective one. Be careful! Even though it's called a low-voltage power supply, the voltages are lethal and not isolated from the AC line.

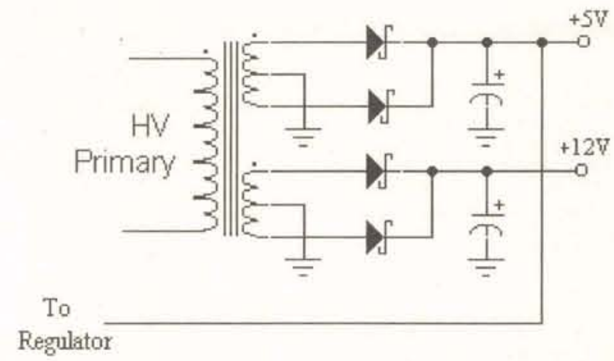
### Shrinking AT Power Supply

**Q.** I'm an electronic technician who has acquired several defective AT switching power supplies rated at 230 watts. The only problem is that the +12 volts is low. Where could I find a representative schematic for one of these power supplies?

**John Najvar**
**via Internet**

**A.** Chances are you can't. This was one of the best-kept secrets of the PC industry, where it was nearly treasonous to even acknowledge you had possession of such a document. Nonetheless, most were pretty straightforward with a few innovations here and there. In the Sept. '96 issue, I did an in-depth article on "PC Power Supply Repair." You can still order that issue through our website at **www.nutsvolts.com**.

But from the information you've given me, I can tell you where to start looking. First of all, only the +5V line is regulated. None of the other output voltages are regulated, for good reason. This is a consumer (not military) switching power supply, and costs have to be kept down. As it turns out, the only output that's critical is the +5V line, which has to be maintained in a narrow range of 4.75 to 5.25 volts — ±5%, or better. Although the other voltage outputs are unregulated, most PC AT switching supplies have their other output currents balanced so that these output voltages seldom veer more than 10% from normal. So, if the +5V line is within tolerance, it means the problem is exclusively in the 12-volt circuit, shown below.




My first thought is that if you have a bunch of these 230W power supplies, they are probably from the same vendor — and it's a good bet that the vendor bought a batch of cheap filter caps from one source. Suspect #1: One or more bad filter caps. Jumper the caps with a good capacitor of equal value and see if the voltage increases or not. A significant increase is a bad cap. Suspect #2: A leaky diode. These come as a pair in one package, and need to be replaced as such. Suspect #3: The power supply can't provide the current your load is putting on it — it may be dragging it down to the point where it can't deliver the goods. If this is the case, you can try increasing the value of the output caps and lower the current demands on one of the other supplies. Just because it's labeled as 230 watts, it's not really. Add up all the output currents and voltages listed, and you'll see it exceeds the "claimed" 230W. Power supply manufacturers rate the 230 watts on "typical" usage. If it still doesn't work, toss it.

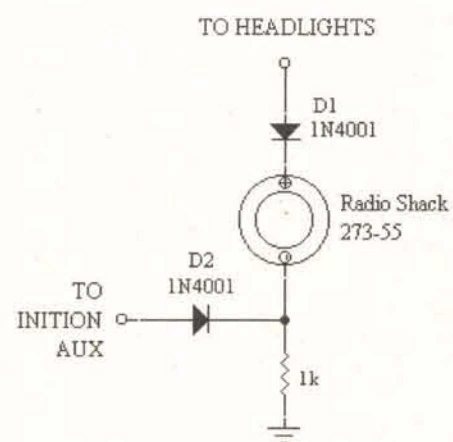
### Lights-On Reminder

**Q.** I live in Florida, which has more than its fair share of rain, and drive a Toyota pick-up truck. My problem is that I way too often forget to turn off the headlights after driving in the rain. So far I have completely depleted two batteries and it's becoming very expensive.

If I could impose upon you, I would like a circuit that would audibly warn me when the lights are on and the engine is off.

**Ted Mylenbusch**
**Keystone Heights, FL**

**A.** Sure, and here it is:




Back in the days of old, this would be called a logic circuit, as in the diodes are steering the beeper's current. When both the ignition and the headlight inputs are high, the beeper is essentially shorted out by D2. The alternator is charging the battery, and you have lights up front. Both diodes are forward biased. Turn the ignition off, though, and it's another story. Now, the 1k resistor has no place to go but to ground, which activates the beeper. Translated, if both HEADLIGHTS and IGNITION AUX are high, you have an AND gate. Both

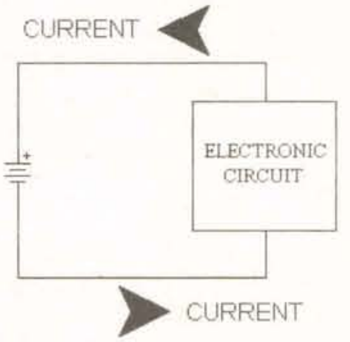
inputs have to be high for the output to be high, and no buzzer. When the lights are on and the key is off, the siren starts screaming its head off.

## Hit The Ground Running

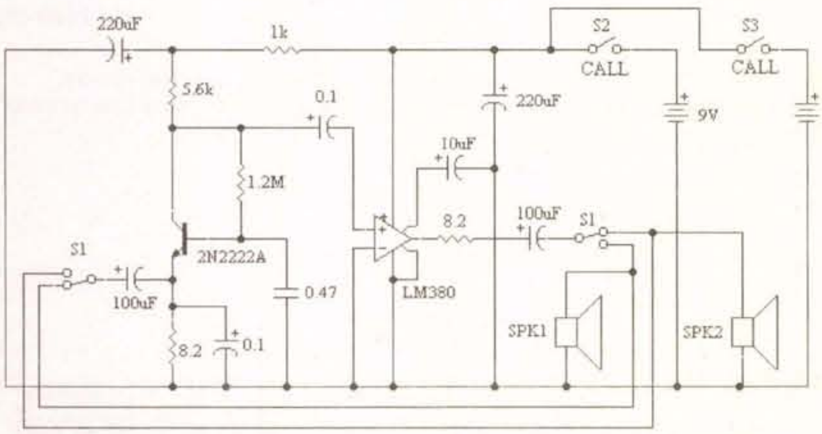
**Q.** I've been studying electronics as a hobby for the last few years, and something has always bugged me. In the battery-operated circuits, I noticed that only the positive voltage is shown as the input voltage. What should I do with the negative half of the voltage from the battery? Should the negative voltage be sent to ground?

**Wayne C. Green, Jr.**
**via Internet**

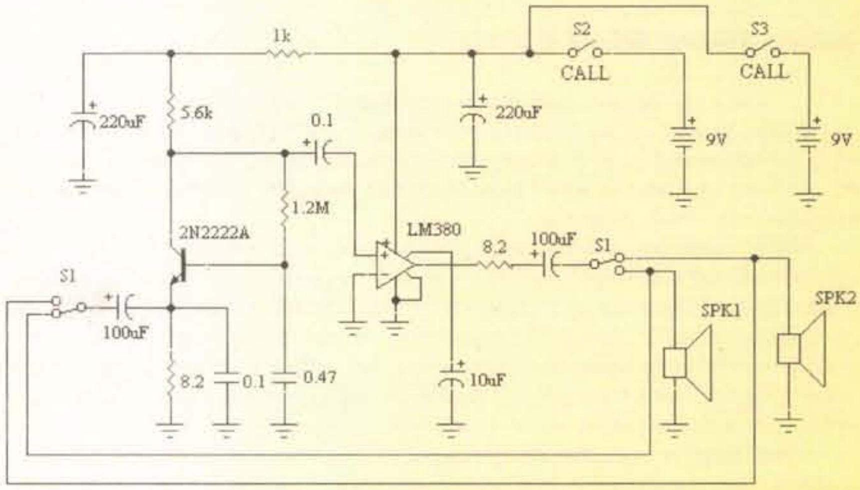
**A.** Let me see if I can put this in a context that covers both battery and line-operated power sources. Electronics operates on the principle of current flow, which means electrons flows from the negative terminal of a power source to the positive terminal. (I know the flow seems backwards, but blame it on Ben Franklin, who guessed wrong when lightning knocked him down instead of up). So here's how it looks schematic-wise.




Now let's expand the electronic circuit part to be ... how about a "Two-Way Intercom?" Here's the original circuit.




And this is how it looks after cleaning up the negative half of the circuit into the GND symbol. Same circuit, same results, but cleaner-looking. Why does the negative go to ground? Because of lightning! Just kidding — it's because it makes sense. If one wire is grounded — planted into earth — that means the risk of electrical shock is reduced by 50%. So in answer to your question, wire your negative battery terminal to ground, which is a common line.




Before I go, I have to stress an important point — ground loops. One of the reasons grounds are shown as a symbol and not a wire is because a wire can generate what's commonly called a ground loop. That is, ALL the current sinks to this point, and like all resistive devices, a ground wire has voltage drop across it, which can lead to instability in a circuit. To avoid this situation, it's recommended that you pick a spot — any spot — on the finished project that you call GND, to which all ground wires terminate. Period, literally. A single point, and you'll never have a ground loop.

## Can a 5881 Turbocharge a 6L6 Amp?

**Q.** I was recently told by a friend that I could turbocharge my guitar amp by replacing the 6L6's with 5881 or KT88 vacuum tubes. I checked a tube chart at www.nostalgiaair.org and found the pin layouts were the same. However, I couldn't compare their electrical characteristics because none were given for the 6L6 tube. I'd appreciate any guidance you could provide on this topic.

**Al Lovecky**
**via Internet**

**A.** You're right, there are no specs for the 6L6 at this site, but simply plugging in a new tube won't turbocharge your amplifier. Why? Because the circuit parameters are the same, so the output wattage will be the same. To gain more performance from a tube upgrade you have to:

- Increase plate voltage.
- Normalize grid bias for the new operating curve.
- Make sure your output transformer can handle the extra power.

Unless you can make *all* these changes, nothing will improve. And unless you know how to shift the bias properly, you can easily end up with less performance than you have now. My suggestion: buy a bigger amp or seek the help of a professional tube guy, not the advice of a fellow musician. BTW, the 5881 is identical to the 6L6GC. Here's a chart showing the difference between them.

| Parameter | 6L6 | 6L6GC | 5881 | KT88 |
|---|---|---|---|---|
| Plate voltage | 360 | 500 | 500 | 560 |
| Plate wattage | 19 | 30 | 30 | 50 |
| Screen voltage | 270 | 450 | 450 | 450 |
| Heater current | 0.9 | 0.9 | 0.9 | 1.6 |

## Mmm, Mmm Good Power

**Q** I made a power supply to run an AT-style motherboard inside my car. The power supply converts +12 volts to +5, +12, and -12. But when I plug my homemade power supply into the motherboard and turn on the power, nothing happens until I close and then open the reset pins. The motherboard then boots properly.

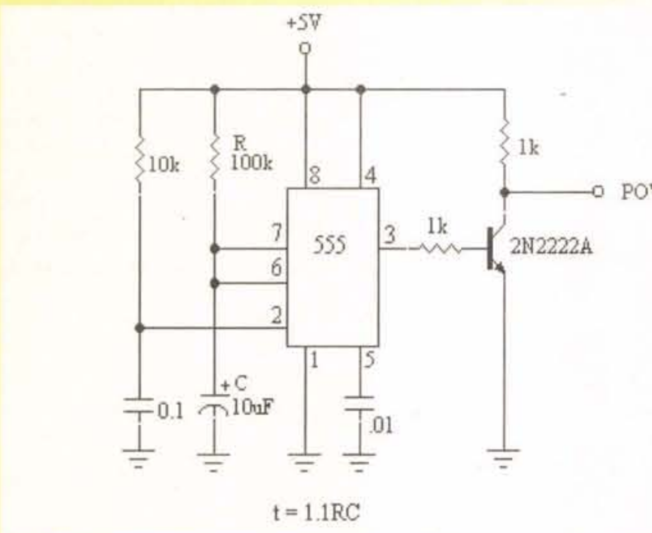
When I connect a desktop AT power supply to the motherboard, it boots up normally without requiring the reset pins to be closed and then opened. If I remove the Power Good (orange) wire from the AT power supply, the motherboard won't boot until I close/open the reset pins. It appears that the problem with my homemade power supply lies with the Power Good signal. I tried tying this line to the +5-volt lead from my power supply, but the motherboard still doesn't boot without the reset maneuver.

What exactly does the motherboard expect from the Power Good line and how do I simulate that in a homemade power supply?

**Tom Paciorkowski**
**via Internet**

**A** When the power supply is first turned on, it takes time for the electronics to settle down. It takes a finite time for the filter caps to charge up, the semiconductors to kick in, and the output voltages to settle down. Typically, it takes between 100 mS and 500 mS before the power supply outputs are within tolerance, depending on the particular unit, and the Power Good line goes high — the cue for the motherboard to power up.

In the AT power supply, this is accomplished using comparator circuitry that guarantees the +5-volt output is within tolerance before applying the Power Good signal. You can do the same thing with your home-built power supply, but this circuit is simpler.




It's basically a one-second delay timer built around a 555 chip. When 5 volts is applied to the chip, the output (pin 3) goes low. After a time determined by C and R, the output goes low and stays low until you shut off the power supply. This output drives a 2N222A transistor that connects to the Power Good input of the motherboard, which will now boot up properly. The values shown are for a delay of one second, which should be plenty of time for your power supply to settle in. However, you can adjust that period up or down by increasing or decreasing the value of R, respectively; the formula is shown on the schematic.

For you musicians and audiophiles, here's another good source for selected tube types: **hereford.ampr.org/cgi-bin/tube**.

I'm presently looking at a software application that may satisfy all tube lovers' needs. Stay tuned, most likely next month.

## Correspondence Studies

**Q** I am interested in taking a correspondence course in computer servicing. I've been looking for ads for these schools without success. There used to be many, such as NW, Coyne, NRI, etc. Are they all out of business?

**Arden Ebert**
**via Internet**

**A** Without real hands-on experience and video feedback, it's difficult to effectively learn computer repair from afar using just textbooks. Consequently, most electrical/radio correspondence schools have been replaced with on-line courses and self-study video tapes. Some of the on-line courses send you a PC to play with, but most rely on visuals and diagnostic tools that are either mailed to you or downloaded from their web site. Prices and course contents vary widely, so it pays to shop around. Here's a short list of places to get you started.

### Correspondence Schools

**NRI**
http://www.mhcec.com/courses.htm

**ICS Learning Systems**
http://www.icslearn.com/ICS/courses.htm

**Foley-Belsaw Institute**
http://www.computerrepairschool.com/

### Online Courses

**Professional Career Development Institute**
http://www.pcdi-homestudy.com/courses/jj/

**INTEC College — Distant Education**
http://www.intec.edu.za/educ/dist_edu.htm

**Oliver Worldclass Labs**
http://www.oliverlabs.com/comp/pc_repair.htm

### Self-Study

**Specialized Solutions**
http://www.quickcert.com/a-plus.htm

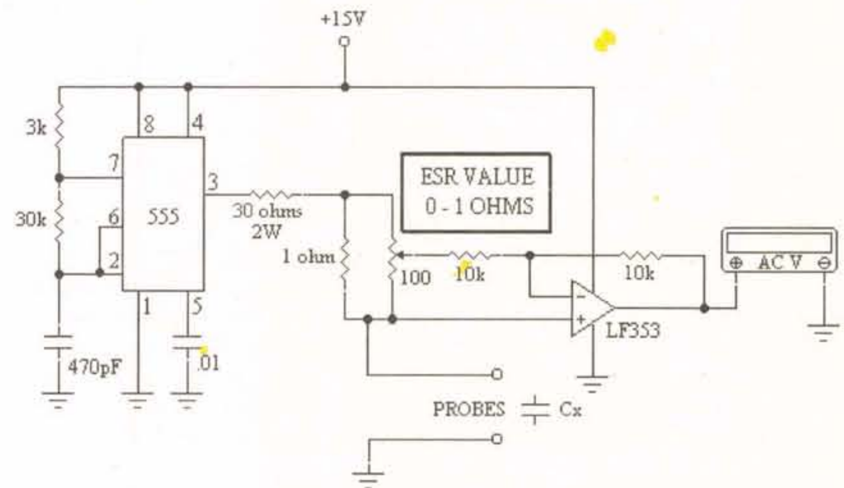
**Marcraft**
http://www.mic-inc.com/mc.htm

## Simpler ESR Meter

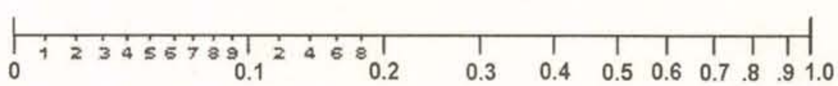
**Q** I read with interest your response in the June 2000 column to the question of measuring ESR in an electrolytic capacitor. For me, this is overkill. I don't need to measure the electrolytic in circuit — in fact, most are in my junkbox. The capacitance meter says they are within tolerance, but I wonder about their ESR because the last two I tried as replacements didn't fix the ripple problem. Do you have anything in the way of a simpler ESR meter?

**Carl Peterson**
**via Internet**

**A** Just so happens that I have one in the hopper — one that almost made it to the June issue except for limited space. So thank you for asking, and here you are.




This instrument uses a low-cost DMM or analog multimeter display. As mentioned in the last column, the ESR (Equivalent Series Resistance) of a capacitor can be measured using an AC voltmeter. This AC voltmeter consists of a balanced bridge-like circuit, where the ESR of the capacitor under test is compared to the resistance of a potentiometer. The 555 chip functions as a 50-kHz squarewave generator. A current of about 180 mA is forced through the capacitor under test. When the ESR VALUE pot is adjusted to the same resistance value as the capacitor's ESR, the output voltage drops to a null. The dial is calibrated in ohms — 0 to 1.00 — and the ESR value can be directly displayed by looking at the position of the knob.




To make a measurement, adjust ESR VALUE until Vout nulls out — it doesn't have to dip to zero, just the lowest point. Read the setting and that's the ESR of the cap under test. This tester is designed for use with capacitors of 100 uF or greater, where the ESR value is less than 1 ohm. Here's a handy reference guide. Just remember the values are typical for computer grade capacitors, and may not be the values found in standard aluminum types. In

other words, a RadioShack 1,000 uF cap with an ESR of 0.9 ohms isn't defective.

| Capacitance Value | ESR Value (ohms) |
|---|---|
| 100 uF | 1.0 |
| 500 uF | 0.5 |
| 1000 uF | 0.1 |
| 5000 uF | 0.05 |
| 10,000 uF | 0.01 |

Because most values fall under 0.1 ohm, I've used a log taper (also called audio taper) potentiometer for more precise measurements. Just make sure that you use a good quality slider pot, and insert it into the circuit with the tapered end above ground (pointing up on the schematic).

**Cool Web Sites**

Portrait of a planet; art from mars.
mars.jpl.nasa.gov/mgs/msss/camera/images/may_2000/index.html
mars.jpl.nasa.gov/mgs/msss/camera/images/index.html

## MAILBAG

Dear TJ:

In my experience, the quickest way to diagnose a dried-out electrolytic is to bridge it with a known-good capacitor of at least half its marked capacitance and at least the same working voltage. In practice, a 100 uF, 50V capacitor and a 40 uF, 450V capacitor were all I needed to diagnose almost all my ills.

**Michael**
**via Internet**

Dear TJ:

The impedance of the headphone amp, page 62 Apr. '00 issue, is not 600 ohms as implied in the emitter follower. Unlike a tube whose plate impedance is high, the impedance of an emitter follower is the base resistance divided by the transistor gain in parallel with the load resistor (guessing <50ohms). The circuit will still work as intended, but it might mislead readers into thinking that the emitter resistor is matching the impedance.

**Paul Futscher**
**Willits, CA**

Dear TJ:

Just received my Apr. '00 issue and stopped at the answer to G. Lehmann about connecting an eight-ohm headset to his Drake receiver. Although the circuit you suggest is admirably biased in the linear region, I can only see about 1 mA peak-to-peak into an eight-ohm load before serious distortion occurs. This works out to be about 1 microwatt RMS. I didn't catch where he wanted the earphones to be used by his dog. Notwithstanding the folklore of the cathode follower having some similarity, don't forget there was a great deal more Class-A power going on in the tube circuit than your "equivalent" circuit is showing. A matching transformer is really the most practical solution, albeit mundane. Audio power is what we are listening to, not voltage similarity across the terminals.

**W. Chou**
**via Internet**

*Response:*

*It's a typo. The value should be 60 ohms, not 600. I wrote this column while in Trinidad using Paint Shop Pro on a small notebook PC (didn't have my CircuitMaker schematic capture software), and viewing conditions weren't always the best. Fortunately, 600 ohms will work kinda, so it's not a total loss. Sorry for the mistake, and thanks for pointing it out.*

***TJ Byers***
***Q & A Editor***

### ULTRA MINI and WEATHERPROOF, "LIPSTICK"

Sleek black anodized, alum. housing, O-Ring sealed & RAINPROOF. Adj. tilting mount. 1/3" CCD, 380 Lines, 0.3 Lux, AGC, Auto Shutter. 9-12VDC @100mA, 4mm, f1.8, 78° FOV real glass lens, NTSC video. <1ounce! IR SENSITIVE. 23mmdX50mm, 36" cable with BNC video & DC barrel jack.

GM-200K, PINHOLE Model. So tiny you can install it directly into a door. Only a 0.9" diameter hole! Specs as above. 90° FOV Pinhole lens. 1/2 once! Size only 23mm d.x35mm long. Think of the places you could put this little jewel.

**LOOK! SPECIAL MAY PRICE, GM-200KSTD..$69**
**LOOK! SPECIAL MAY PRICE, GM-200KPH....$69**

### SALE on ALL TYPES of COVERT CAMERAS, all available with audio,

Specification for all models include: 1/3" CCD, 410 Lines Res., 0.3 Lux sensitivity, Power from 9 to 12VDC @100mA, 90° FOV lens except dome and PIR which are 80°, All focus from 2 ft. to infinity. Standard NTSC video out. SENSITIVE to IR. note: Smoke & Motion detectors not functional, Clock & Exit operate normally. Dome is 3.5"H x 5.5"Diam. Don't see what you want? We can put a camera in anything you desire.


**Smoke Det., Motion Det., Clock or Dome Camera, Special...$69ea. Exit Sign, Special.....$79ea. Please add $10 for audio. (any model)**

### WORLDS SMALLEST ••• 100mW ••• VIDEO TRANSMITTER, ON SALE


Incredibly only 0.9" x 0.8" x 0.37" Transmits crystal controlled hi-res. images with 100mW output! The transmitter you've been waiting for. Shown actual size. Much smaller than the 9V battery which powers it. Draws only 35mA! Factory tuned. Receive on cable channel 59. Will work with color or B&W cameras. UHF Bow tie antenna with balun and 3' F cable for TV included. Perfect with our GM1000A. **SPECIAL TVX-100..$159 with GM1000A CAMERA..$209**

### NEW, 9" SECURITY MONITORS

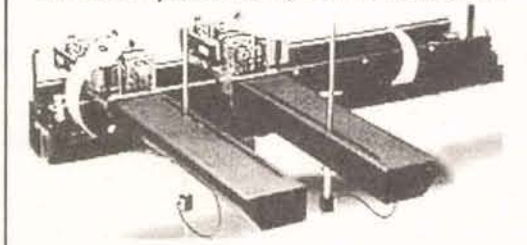
We were fortunate to obtain these Hi-res 700 Line. B&W units. Original manufacturers boxes, 90 day warranty. BNC video in and loop through. Rugged steel case. Current production model. Limited qty. They will make your video look super!

**SPECIAL...$119.00ea. 2 for $229.00**

### PORTABLE MINI PRINTER, 40 COLUMN, with INTERNAL NI-CAD POWER!

The model SD222-1000 is a NEW and very cool, self contained, alphanumeric, impact type printer. It features a standard parallel port and an internal Ni-Cad power supply. Can also be powered via the 9VDC power adapter supplied. Uses standard 2" wide paper rolls available everywhere. Has self test function and diagnostic mode. Can emulate Epson and Citizen 560. It will print from the LPT port of your PC. Very rugged and well made. Perfect for any remote printing or data logging application. Size: 8"L x 4.1"W x 3.5"H. **OUR PRICE.......$49ea. or 2 for $75**

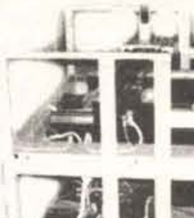
### Robotic Sample Processor, from Cavro Scientific



Bring your automated system up to speed with this Robotic Sample Processor. It is an XYZ module that is fast and flexible with user friendly software available. (NOT SUPPLIED) Install the RSP XYZ as the nucleus for your new system. Of course the system can be configured for many other motion automation applications as well. Your imagination is the key. Overall size: 31"W x 22"D x 7"H, X travel (dual long axis) is 22", the Y travel (dual short axis) is 12", the Z axis is limited only by the length of the rod insertd into the linaer bearing unit. (user supplied). The module is supplied with dual arms as pictured, variable sensitivity liquid level sensing and encoders. The electronics support a number of auxiliary devices including diluters, valves, peristaltic pumps, sample racks and single, multichannel or cap piercing probes. Mix and match from different Cavro modules and build the system that fits your needs. The RSP can be controlled using a simple user interface (We do not have the info). Software controls the arm movements and its accessories as well as performing diagnostics and data handing functions. For more information please see www.cavro.com

**Robotic Sample Processor, RSP-XYZ.....$695ea.**

### IT WILL MOVE YOU! PRECISION, XY TABLE.



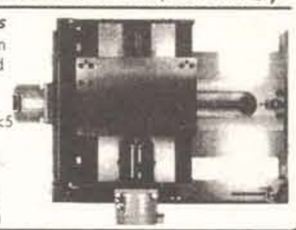
Long travel, Really nice and like new, (removed from a $100K film scanner) Super X-Y table offers approximately 24"x 24" of travel. The system is shock mounted to a rugged tubular steel, wheeled base with a creme colored powder coat finish. Dual, heavy duty, Berger RDM-566-50, 1.3A, 1.4ohm stepper motors are attached. Heidenhain 500ppr encoder on one axis. Perfect for laser system. Overall size is 55" x 44" x 39" Ships via truck.

**Sorry Last One.......$1295**

### WOW! COMPUMOTOR, 4000 MOTION CONTROLLER PLUS, TWO, SERIES LE, STEPPER MOTOR DRIVERS.

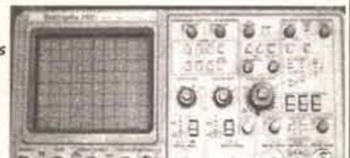
*Motion*, 1 to 4 axes of step & direction control. Accepts encoder position feedback.
*I/O*, Optically isolated programmable inputs (24) and outputs (24) compatible with industry standard signal conditioning products.
*Features*, 4000 Programmer/Operator Panel, Detachable can be mounted remotely. Dedicated jog function for each axis. Four-line, backlit, Liquid Crystal Display (LCD). Six soft-function keys labeled by the LCD change definition as needed. Sealed membrane keypad.
*Language*, Simple BASIC-like motion control program language. (No software supplied.) Multiple programs may be entered and saved. Feedrate override allows operator interaction. Insert, edit, copy & delete functions. User-defined operator prompts. Linear interpolation on up to four axes. Teach mode uses analog joystick (not supplied) inputs or operator panel jog keys.
*Interface Capability*, Remote programming capability over RS-232C and IEEE-488; remote program downloading and uploading. Second RS-232C port for operator messages or control of other devices. **Special System,.....COMP4000/LE....$1495 Ltd.Qty.**

### DOVER AIR BEARING X/Y TABLE, is ULTRA PRECISE,



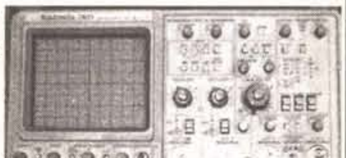
Like New, The ultimate in precision motion control. Leadscrew operated air bearing tables with 1-20 Microns typical repeatability. Straightness, <1 micron each axis, angular error, <1 arc/sec. Squareness, <5 arc/sec. Unit has 4"x5" travel with two Compumotor LE57-51-MTR steppers attached. Ready to play with our Compumotor 4000 series system above. **DOVER-B45..$949 with COMP4000/LE & cables $2250**

### TEKTRONIX 2465, 4 Chan., 300MHz, O'Scope, With on screen waveform stats



One of the most popular & powerful scopes available at a reasonable cost. Features: 500ps/Div sweep, 2mV/Div. vertical sensitivity, 1Mohm / 50-ohm input, 500Mhz trigger bandwidth, four channels. On-screen waveform cursors provide vert. & horiz. scale factors, trigger level, voltage, time, freq., phase, ratio values and mode indication. Complete with 2 probes, and manual. Excellent condition. 90 day warranty. **Very Ltd. Qty.....$2195.**

### TEKTRONIX 2445, 4 Chan., 150MHz, O'Scope, With on screen waveform stats



One of the most popular & powerful scopes available at a reasonable cost. Features: 500ps/Div sweep, 2mV/Div. vertical sensitivity, 1Mohm / 50-ohm input, 500Mhz trigger bandwidth, four channels. On-screen waveform cursors provide vert. & horiz. scale factors, trigger level, voltage, time, freq., phase, ratio values and mode indication. Complete with 2 probes, and manual. Excellent condition. 90 day warranty. **Very Ltd. Qty.......$1295.**

### NEW, "COLOR STEALTH CAM", MICRO SIZE, with AUDIO!

That's right! COLOR! In the same size package too! Sleek aluminum housing fits like a glove! Removeable mtg. bracket & a 1.3M cable with BNC vid., RCA aud., (internal mic) & DC pwr. jack for, no sweat hook up. Why fool around with an open P.C. board? Now you can have the "COLOR STEALTH CAM"

- 1/3" • 350 Lines
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- 1<ounce!
- 0.7 Lux • AGC
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- Std. 7 mm, 56° FOV lens
- NTSC video
- Size: 31mm sq. x 28mm d.

**GM-4000S-STD w/audio SPECIAL $89ea.**

### B & W "STEALTH CAM", MICRO SIZE, with AUDIO!

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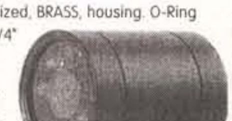
**SPECIAL...$69ea.**

### NOW YOU CAN SEE WHAT THE "FISHES ARE DOIN' (down 60 ft.) UNDERWATER B&W CAMERA with INTERNAL, INFRA-RED ILLUMINATOR!

Sleek black anodized, BRASS, housing. O-Ring sealed & WATERPROOF. Adjustabe mount incl. Specs: 1/3" CCD, 400 Lines res., 0.05 Lux sensitivity, AGC, Auto Shutter. 12VDC @225mA, 4mm, 78° FOV lens, A real glass lens. NTSC video out. Superior construction. SENSITIVE to IR. Ultra small Size only: 1.25"diam. X 2" long. With 60 ft. cable. Perfect as a remote aresa inspection camera. Great for general outdoor use as well. **GM-300KIR.......$179**

### NEW! NOW YOU HAVE COLOR (down to 60 ft.) UNDERWATER.

***Built-in WHITE LIGHT LED'S,*** Sleek black anodized, BRASS, housing. O-Ring sealed & WATERPROOF. Adjustabe mount incl. Specs: 1/4" CCD, 350 Lines res., 0.5 Lux sensitivity, AGC, Auto Shutter. 12VDC @120mA,4mm, 78° FOV lens, A real glass lens. NTSC video out. Superior construction. Ultra small Size only: 1.25"diam. X 2" long. With 60 ft. cable. Perfect as a remote area inspection camera. Now with six super bright, white LED'S! BRAND NEW,



**GM-400KW-LED............$219ea.**

### END FIELD of VIEW GUESSWORK! 3.5 to 8mm VARI-FOCAL LENS

Brand New, super f1.8 lens allows you to smoothly adjust from a 97 ° FOV @ 3.5mm to a 4° FOV @ 8mm. Now you can frame your area of interest just the way you want it! Standard CS-Mount with adjustable focus and iris. **SPECIAL.....$79ea. or 2 for $149**

### SUPER, MINI C-MOUNT CAMERAS, Super sensitive, GM410 or the general purpose GM412,

The GM-412 specs: B&W, size 1.5"sq X 2.4"L, 250,000 Pixels, 380 Lines Resolution, Sensitivity 0.3 Lux, The GM410 specs: size only 1.5" SQ. x 1.6"L, >270,000 Pixels, 410 Lines Res., Sens. 0.05 LUX., Both

cameras are 1/3" CCD with AGC & Electronic shutter. 12V @110mA power. NTSC out. IR SENSITIVE, BNC video out, Both use std. DC pwr. jack. Aluminum housings with dual threaded top and bottom mountings. True performance not hype! These cameras will outperform *ANY* camera in this magazine. Multi- lens options are available to exploit their superior performance. GM412 shown bottom. GM410 shown top. Prices are less c-mout lens.

**GM412......$99, GM410.......$169**

### C-MOUNT LENS OPTIONS:

| | | | | |
|---|---|---|---|---|
| LOW LIGHT: | 16mm, | f1.6, | 15° FOV | ..........$39ea. |
| | 8mm, | f1.3, | 40° FOV | ..........$49ea. |
| | 4mm, | f1.4, | 78° FOV | ..........$49ea. |
| STANDARD: | 4mm, | f2.0, | 80° FOV | ........$24ea. |
| | 6mm, | f2.0, | 60° FOV | ........$24ea. |
| | 8mm, | f2.0, | 40° FOV | ........$24ea. |
| | 12mm, | f2.0, | 28° FOV | ..........$24ea. |

### NEW! Low Cost MICRO CAMERAS,

1/3" CCD, 410 Lines Res., 0.3 Lux sens., AGC, Auto Shutter. Pwr. from 9 to 12VDC @100mA, 250k PIXELS, Std. model, 4mm, 78° FOV lens, Pinhole, 90° FOV. A real glass lens. Both focus from 10mm to infinity. Std. NTSC video out. 1/2 ounce! SENSITIVE to IR. Size Std: 1.25"sq. x 1"d. PH is 0.6"d, 1.6M long wiring harness with connectors included. WARNING: Don't confuse these models with LOW RESOLUTION, HIGH LUX C-MOS CAMERAS.

**GM-1000A-STD......$59ea.**
**GM-1000A-PH........$59ea.**
**GM-1000A-CMNT..$59ea.**

### Micro Lenses for GM1000 series

**2.5mm, 150°, FOV, f2.0 .....$22ea.**
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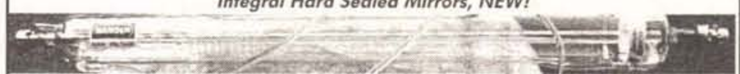
**4.3mm, 78°, FOV, f1.8....$22ea.**
**6.0mm, 60°, FOV, f2.0....$22ea.**
**5.0mm, 70°, FOV, PH.....$22ea.**

### 6V@12AH SEALED, RECHARGEABLE,

New Panasonic, LCR6V12P1. Tough to get at a discount. Very compact. Two top mounted 1/4" faston connectors. Perfect for high drain projects. Size: 5.9"L x 3.7"H x 1.9"D

**2 for $20, or 10 for $89**

### CO2, 120Watt CW, SEALED GLASS LASER HEADS
#### Integral Hard Sealed Mirrors, NEW!



High quality water cooled heads. Were originally designed for medical application. All models are similar in construction. Size of the model 103: 60"L x 3.2"diam., Model 160: 44"L x 3.2"diam. Model 135: 35"L x 3.2"diam. Power requirement, model 103, 40KV trigger with 25KV @ 10 to 30ma operating current. Model 160 and 135, 30KV trigger with 15-20KV @ 7 to 20mA operating current. These are not toys. They must conform to Class IV CDRH regulations when assembled into a functioning system. Perfect for engraving, cutting and drilling most materials. Only three available. Only one 200W system. We don't expect any more.

**Special 200W dual tube head with metal housing & dual power supply.......$4395. Limited Quamtity.......100+Watts.....$1475., 35Watts.....$895.**

### SUPER SPECIAL OFFER, ACCESSORIES to COMPLETE YOUR CO2 SYSTEM!

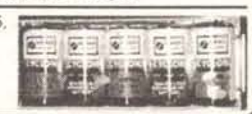
**CO2 Power Supplies:** for 100Watt+ Tube..$495ea. Supply for 35Watt Tube..$399ea. 100W, power supplies are used, tested and guaranteed. 35Watt, power supplies are NEW! Supplies are not sold without laser tube purchase. ***Articulated beam delivery arm with focusing hand piece. Brand new. A fantastic item. Regular price >$3500.ea! With purchase of tube..$895ea. Arm without laser tube...$1295ea.***

### A NICE ASSORTMENT OF $CO_2$ and YAG OPTICS TO MAKE YOUR LIFE EASIER!
#### All NEW and factory boxed first quality, BK-7 glass or ZnSe.

| ITEM # | NAME | DESCRIPTION | MISC. |
|---|---|---|---|
| RP10-02 | RISLEY PRISM | 1deg. AR @1064 & 540 to 650nm | Alignment/multi wavelength path. |
| RP10-03 | RISLEY PRISM | 1deg. AR @450 to 650nm | Alignment/multi wavelength path. |
| BS10-01 | BEAM SPLITTER | AR @45deg. for 1064nm | YAG or $CO_2$ High Power |
| BS01-02 | BEAM SPLITTER | AR @45deg. for 1064nm | YAG or $CO_2$ |
| DUAL-01 | MIRROR/HT-HR | HT @45deg. for 532nm, HR for 1064nm | High Power |
| PLCV-01 | DUAL FREQ LENS | HT for 1064 and 6328nm >98.5%, 113mm | Focus C02 & HeNe ZnSe |

**Order by Item Number. All models priced at $25ea. or 2 for $39**

### 10V @ 2.5 AH SEALED, LEAD ACID, PACK.



Each pack has 5, cells are arrainged as 1X5 cells. Enclosed in an ABS outer shell. (removed for photo) Perfect for high drain applications. Make custom packs of any rating. Size: 7.5"L x 2.8"H x 1.5"D

**SALE! 6-five packs for $20, 40 for $99**

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# The Hidden Sounds on Your Telephone Line

by ML Shannon

Have you ever thought about what might be happening on your telephone line while you are not using it? Probably not. After all, what could happen? Unless ... you start to wonder ... am I suggesting that someone might have tapped your phone?

No. At least not in the normal meaning of 'tap' where someone is monitoring your calls. If someone were, you probably wouldn't hear anything.

I refer here to the use of your line to make calls. And for testing purposes. Voices, sometimes, and exotic sounds like tones, chirps, rotary dialing clicks, analog data, and other noises are some of the sounds you will hear using the simple device described in this article. You can build it yourself for about $10.00.

More on this coming up, but first a look at telephone systems and wiring. It may be in any of several configurations, so I will use my neighborhood in San Francisco as an example.

When you first have telephone service installed, a computer system called COSMOS, or COmputer System for Mainframe OperationS will check your address to determine if there has previously been service there, and if so, the cable and pair numbers that were used. You are then assigned a number with a prefix in your area; a test is run to determine that the line is in working order, and the mainframe computer is programmed to turn on the Dial Tone. This may be at the Central Office (CO) or a technician may check the wiring at the other end, and from there request Dial Tone from the CO.

Now, your pair of wires begins its path to your phone from the Central Office. Your line is ported from the 'switch' – the mainframe computer – to a distribution frame. The frame, at least with the more modern systems, holds a large number of small printed circuit boards – 'cards' – each of which controls about eight individual lines. The computer and the frame, are called OE – Originating Equipment.

Then your pair – along with many others – goes from the distribution frame into the cable vault, frequently located below ground level, and then into the outside world. Your pair may be within any of various different types and sizes of cable, but typically, it will be an F1 Feeder Cable with 1,200 pairs. This wiring, once it leaves the CO is called the Outside Cable Plant.

PHOTO 1

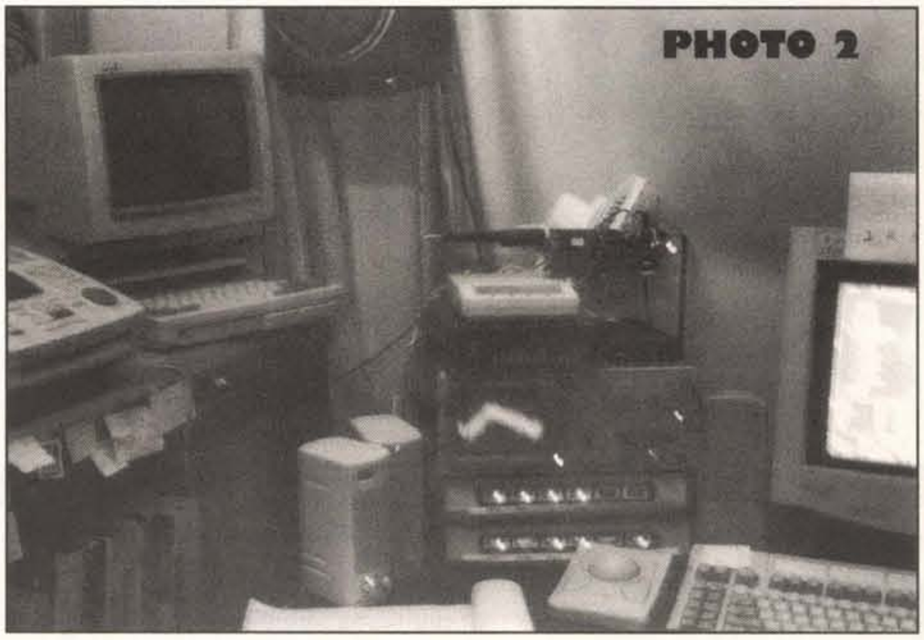


PHOTO 2

### Appearances

From the cable vault, there may be any number of appearances on your line, an appearance being a place where the line can be physically accessed. This includes:

#### Junction Points

A Junction Point (JP) is an underground maintenance area located beneath the street and accessed through a manhole where you sometimes see several Telco trucks parked. The large 'accordion' tube you see provides fresh air as methane gas is sometimes present.

#### Bridging Boxes

A 'B' or 'Bridging' Box – sometimes called Service Area Interface, which is usually located on a street corner or in an alley – is about three by five feet across and two feet deep.

#### Splicing Boots

In some areas, phone wires are overhead on telephone poles called 'aerials' so the pairs will go to an Aerial Service Terminal also known as a 'splicing boot' at the top of the pole.

Eventually, your pair of wires enters your home or apartment building one of two ways. Aerial wiring uses a Drop Wire that goes from the telephone pole to a small connection box on the outside of the building. Older types were an aluminum can about the size of a brick called a Single Pair Station Protector (SPSP) and newer types are plastic, called a Telephone Network Interface.

Underground wiring enters through a conduit and terminates at a panel often called a 66 block. The term '66' is, apparently, an old Bell System part number for a connection block with a 25 pair capacity.

Both of these are known as the Point of Demarcation or usually just 'demarc.' Beyond that, the (inside) wiring is the responsibility of the building owner.

This wiring – your pair from the CO to your telephone – is called a Loop or Local Loop – a loop of wire from the CO and back.

### Multiples

What is significant about all this is that the pair of wires used for your line probably has been used for someone else's phone sometime in the past and it might still lead to a different location called a Multiple.

In the Junction Points – or if

above ground, the Splicing Boot – a certain number of pairs separate from the distribution cable and lead into your building. These pairs then terminate in that building – that is, they end there and don't double back.

So, when your pair separates, it is disconnected from continuing on to the next appearance by removing a jumper. But once in a while, this jumper is not removed, which means that your pair does continue on to another Junction Point and possibly into another house or apartment building. This is one way an illegal wiretap can be set up, if the tapper knows the right cable and pair numbers and can get into the JP.

Now, in a situation where this is true, your line will go into the 66 block at this other location and then might go to an unused modular block or may be connected with the heavy wire with thick black insulation used in older buildings and to a connection block that uses spade clips and screw terminals. It may have been there for years without anyone using it, especially the older type of wiring, and the block might be behind some piece of heavy furniture that hasn't been moved in years, such as a bookcase.

On the other hand, the block might be accessible, perhaps in an apartment that has been vacant for some time.

## Sources

Amplifiers, parts, cables
**Alltronics**
2300 Zanker Road
San Jose, CA 95131
www.alltronics.com

**Electronic Rainbow**
6227 Coffman Road
Indianapolis, IN 46268
www.rainbowkits.com

DTMF Decoders
**Motron Electronics**
310 Garfield Street, Suite 4
Eugene, OR 97402
www.motron.com

**JDR Microdevices**
1850 10th Street
San Jose, CA 95112
www.jdr.com

### Sleepers

Now, one day, someone moves in, and they happen to plug a phone in to the modular jack and it works – there is dial tone. It becomes an extension phone on your line! Now, they may not realize this, they may assume that their new service has already been turned on since this can be done overnight. So, they would be able to make calls on your line. This is called a "Sleeper On The Line."

Incidentally, it is also possible that you might be a multiple on someone else's line. You can use the amplifier in this article to find out by checking any unused connection blocks you may have. And should you find dial tone, you will want to know whether or not it is your own line. You can do this by calling yourself which, of course, will get you a busy signal. But if your phone does ring, then you know you are calling from another number. Or you can use ANI, a number you call that has a computerized voice that reads back the number you have called from. Like other test numbers, ANI is proprietary but if you dig around on the web, you will eventually find one for your area.

### The Hidden Sounds

It is not all that rare that there is a sleeper on your line; it does happen. So, you will, of course, hear the ordinary conversations that people make, unless there is something unusual happening at the other appearance. Or something unlawful, in which case you might want to immediately call 611, report 'unknown trouble,' and hope like heck the telco technician finds the sleeper!

What does the law — local and Federal — say about using this simple device? You would be well-advised to consult an attorney, which I am not. But I do have an opinion. If you use it to listen in on a conversation that is taking place on an extension phone of your own line and the people talking are not made aware that you are listening, then this is unlawful.

As to crosstalk, you probably won't be able to make out much of what is being said, but you are not 'tapping' the other lines. You are simply monitoring your own line and someone else is "using" it without your permission.

Now with Telco technicians using your line, well, this is problematic. I suspect that they aren't really supposed to use a person's line without their permission, but the Communications Act of 1934 may apply here — accessing any line for maintenance purposes — another question best answered by an attorney.

### Telco Technicians

Here is what happened to me while researching one of my books.

When telco technicians are making routine tests on the lines, or installing a new line, they go to an appearance, typically a B-Box. There, they need to call the Central Office and arrange to 'get dial tone' on a particular pair. And to do this, they need an available pair to use to connect their test or 'butt' sets. In some places – cities – there is a 'floater,' a line set aside for telco people for this purpose. But in others, there is no floater, so the technician just picks a pair that is 'handy.' I will explain.

Next time you see a technician working at an open B-Box, go over and have a look. On the inside of the door is a pair of terminals. It is these that the test set is connected to. From these terminals is connected a short pair of wires with clips on the end. These are used to connect to one of the punch down connectors in the B-Box. And since these wires are only so long (about 18 inches), they will reach to only so many of the terminals. So the technician picks one at random that is within reach, sets their test set to 'listen only' to see if the line is in use (at least most of the time they do!), and then uses it. They will call into the CO, answer pages, or maybe check their voice mail. Or, on rare occasions, they may make a few personal calls which can be very interesting sometimes!

And that's what happened to me. Quite a few times over six months or so, the techs were using my line. Unfortunately, this was my data line, and so I kept getting disconnected from the Internet without, at the time, knowing why.

In addition to voice conversations, there are other things you may hear.

### Data

Where once the most sophisticated device telco installation people carried was the "butt" set, today they may have a small data terminal called Tele-Tech. These little gems

It has been my experience that many telco maintenance people are friendly and will chat with you especially if you know some of the terminology. So, you can always try. Ask if this B-Box goes to your address, or if they can check for multiples, or whatever interests you. I have had some fascinating conversations with telco people. But, of course, they won't tell you everything they know ... Incidentally, if they happen to be having a conversation with their butt set, be polite and wait till they are through rather than interrupting them.

are used to connect to various telco facilities and I just happened to hear one in use a few months ago. A technician was (again!) accessing the B-Box half a block away that contains the distribution cable leading to my apartment building and I heard the sound of slow analog data (later I learned it was 9600 baud) coming from the speaker. And, as I had a DTMF decoder (Photograph 1) on the line, I was able to get the 800 number the tech had called!

### Crosstalk

We have all heard crosstalk, the faint sounds of other people's conversations that 'leak' into our lines. You may hear this, sometimes, especially in an area where moisture gets into the lines, and even more so if the cables are very old and use cloth insulation. This frequently happens after an unusually heavy rainfall. Here in San Francisco, it was once so bad – during El Nino incidentally – that people in this apartment building could actually converse with each other! It was scratchy, and you had to raise your voice quite a lot (perhaps like Mr. Bell demonstrating his first working system before Congress), but nevertheless communicate.

### Test Tones

Another of the hidden sounds you may hear are the various tones used for line testing. These may be transmitted at certain intervals, but this will vary from one location to another.

### Tone Slope

This is a series of tones that sounds like a musical scale. It is used to check for line losses at different frequencies. It is quick, lasting less than a second, and sometimes repeats after a few minutes; possibly because the first series indicated some line loss.

### The Milliwatt Test

This is a 1,004 Hz tone at 0 dB tone used to check for line losses, among other things, such as capacitance losses caused by wiretaps and forgotten multiple appearance points. It is very loud, so if you have the volume cranked up, it will definitely get your attention!

### Sweep Tones

This is an audio tone that starts at just under 300 Hz and increases in frequency to a little over 3,000 Hz. Also, the higher end of this tone range detects losses from some inductive devices on the line such as a tap. The reason for this particular frequency range is that telephone systems have a bandwidth of 300 to 3,000 Hz. It was also used, so I hear, to trigger or detect an Infinity Transmitter – a type of surveillance device that worked on telephone systems back in the 50s.

Most of these tones are used late at night, and sometimes can cause your phone to "try" to ring. A feeble sound, not quite a normal sounding ring, but one that may wake you up. You have probably experienced this before. Now, you know what it was!

PHOTO 3

Other tones you might hear include: 440/1,004/2,800 Hz (gain/slope tests); and 2713 Hz to activate Remote Isolation Devices (RIDS), a Maintenance Termination Unit (MTU), or Network Interface Unit (NIU).

### Incoming Calls

When someone calls the line you are monitoring, you will hear a loud low frequency 'buzz' coming from the speaker of the device I will

### Telephone Systems Information

**http://mirror.lcs.mit.edu/telecom-archives/**
Telecom Digest and Archives has a nice selection of links to sites about telephones. Something for everyone.

**http://www.educatorscorner.com/experiments/1wav/signals1.html**
Here at Educators Corner, you can listen to recorded sounds of various frequencies to use as a reference for the test tones described in this article. And, if you like, you can also listen to helicopters, departing 747s, whales, and jackhammers.

**http://www.cisco.com/warp/public/788/net_signal_control.html**
From Cisco, an excellent tutorial on the basics of telephone systems.

describe later in this article. This ringing signal is usually between 20 and 72 Hz (with 20 Hz standard in the US) at a potential of between 40 and 150 volts (with 90 the US standard), depending on the length of the Local Loop. The ring signal duration is one-half to one-and-a-half seconds.

Turn the volume down before you answer or you will get feedback from the speaker. (And maybe a little from the person who called you when they hear the screeching sound!)

### Environmental and Other Monitoring Systems

There are businesses that have facilities that require climate control, meaning a controlled temperature and humidity, but which are frequently unattended. So, they have monitoring systems set up which they can call to get a computer-generated report. Some of them will also open a microphone so that the caller can hear any unusual sounds in the area.

If there should be "trouble" on one of these lines, a telco technician might be notified via their beeper to call in for a 'trouble ticket' and, if the tech happens to use your line, you will hear both them calling in for messages and the synthesized voice of the automated system.

### RTUs: Remote Test Units

There are different types of remote testing devices, including the Harris-Dracon DATU – Direct Access Test Unit. As I understand it, this is a gizmo that is attached to the distribution frame and can make a direct connection to any pair of wires.

The telco technician calls the access number which is answered, usually on the second ring. It is answered with what is much like an ordinary dial tone, followed by Touch Tones that the technician uses to activate various test functions. One of these is listening on the line – the tech can hear conversations on any line they use the DATU on, which is apparently frequency-inversion scrambled. But we know just how "secure" that is, don't we?

### About the Tones

The numbers (Hz) may not mean anything, and unless you have perfect pitch or happen to have a scope (Photograph 1) on the line as I did in my experiment, you may wonder how you can tell one tone from another.

Some of them can be identified by logging elsewhere on to the web sites listed in the side bar, but as an example, the telephone dial tone is 350 and 440 Hz (together) which is lower in frequency than most test tones.

Others can be heard by dialing telco test lines, which usually have two zeros in the assigned prefix such as 440-00xx or 923.xx00. Since these numbers are considered to be proprietary (as far as I know), they can't be published here and, at any rate, they tend to change periodically.

### The Device

Okay, already, what the heck is it? Hearing what is happening on your line is done with a simple device called a Listen-Down or Listen-Down-The-Line amplifier. This is nothing more complicated than a small amplified speaker connected to the line through a pair of .01 uF capacitors.

There are two ways to assemble this nifty device. You can get a small transistorized amplifier from any number of places – such as Electronic Rainbow or Alltronics – and connect it to a small speaker from your junk box. But the easiest, fastest, and least expensive method is to use a multimedia computer speaker. No, this doesn't mean tearing into the $$ Altec system with the SuperSubWoofer on the family computer which could get you into deep trouble. Most computer stores have low-cost speaker sets. The ones in Photograph 2 cost only $10.00.

### The Connections

If you are anything like I am, when you start a new project, even a small one, you want to have everything you need to complete it. All you need is:

- Standard RJ-11 modular telephone cable.
- A modular splitter.
- One cable with a plug that fits the amplified speaker audio input.
- Two .01 uF disk ceramic capacitors.
- And a few inches of fine (AWG 22 or so) solid wire.

Clip the phone cable and strip off about two inches of insulation. Carefully trim off the synthetic fibers and wrap the hookup wire tightly around it. Then splice in the leads from the capacitors and solder them. The other ends of the caps go to the speaker cable. The capacitors block the 48-volt DC line voltage while allowing the audio through.

Now, apply power to the speaker, plug the modulator connector into a phone jack using the splitter, turn the volume up, and lift the phone's receiver. You will hear the dial tone coming from the speaker.

### Adding a DTMF Decoder

Should you hear a sleeper and wonder what number they are calling, you can easily add a touch-tone decoder as shown in Photograph 1. They work from an audio signal – they are not connected directly to the phone line which could damage them – so all you need to do is take the audio output that goes from the amplified speaker to the other (left) speaker and plug that into the decoder.

Take your phone off-hook and dial a few numbers while adjusting the volume until you see the digits clearly displayed.

You're done. Now, sit back and listen to the hidden sounds on your telephone line.

If you hear something not covered in this article, I would like to hear from you. **NV**


### About the author

ML Shannon is a San Francisco writer, author of three books on electronic surveillance, and graduate of a two-year technical school in electronics. He has worked "both sides of the fence" as an employee of two corporations who designed and built surveillance equipment, as well as a technician for a professional TSCM countermeasures company.

Shannon has been a guest speaker on surveillance technology before scanner clubs and law enforcement agencies, and has been interviewed on radio talk shows and television.

He is presently at work on a new book, *Cyber-Street Survival* which is a beginner's guide to privacy and security on the Internet.

He can be reached at P.O. Box 192171, San Francisco, CA 94119-2171 or E-Mail **mshannon@fusionsites.com.**

# Events CALENDAR

## AUGUST 2000

The Events Calendar is a free service for publicizing electronic events such as amateur radio hamfests, flea markets, etc. If your organization is sponsoring an event and would like a free listing, contact us at least 60 days in advance. Include your flyer, estimated attendance, name of the person to contact, and phone number.

Complimentary issues are available upon request for distribution to your attendees. A street address for UPS is required.

While we strive for accuracy in our calendar, we can not be responsible for errors or cancellations. The information contained in this column is for the use of the readers of *Nuts & Volts* and may not be republished in any form without the written permission of T & L Publications, Inc.

All listing information should be sent to:
**Nuts & Volts Magazine**
**Events Calendar**
430 Princeland Court
Corona, CA 92879
**Phone** 909-371-8497
**Fax** 909-371-3052
**E-mail** events@nutsvolts.com

### AUGUST 4-5-6

**IL - ELGIN** - Radiofest. Ramada Hotel, 345 River Rd. ARCI, POB 1139, LaGrange Park, IL 60526. E-Mail: arci31280@aol.com

### AUGUST 5

**IL - CARLINVILLE** - Hamfest. Macoupin County Fairgrounds. Talk-in: 146.82- or 443.400+ 103.5PL. Macoupin County ARC, Tim Jones 217-627-2355. E-Mail: KA9VIV at jester25@royell.net

**MI - ESCANABA** - Hamfest. Delta County ARS, John Anderson WD8RTH, 906-789-6950. E-Mail: wd8rth@arrl.net

**MI - TAWAS** - Hamfest. Iosco County AR Enthusiasts, John Hanley KA8AIP, 517-756-2845. E-Mail: ka8aip@centurytel.net Web: http://www.oscoda.net/icare/

**MO - SPRINGFIELD** - Hamfest. Southwest MO ARC, Woodvall Moore W0ODY, 417-833-2248. E-Mail: w0ody@arrl.net Web: http://www.smarc.org

**NM - ROSWELL** - Hamfest. Pecos Valley ARC, Vernetta Verasso KC5WKA, 505-627-7777. E-Mail: kc5wka@dfn.com Web: http://www.pvarc.com

**NY - ITHACA** - Hamfest. Tompkins County Airport. 7am-2pm. VE testing. Talk-in: 146.97. Tompkins County ARC, Richard Spingarn AA2UP, 607-387-5251. E-Mail: richard@eagleprint.com Web: http://www.compcenter.com/~tcarc

**OH - COLUMBUS** - Hamfest. Voice of Aladdin ARC, James Morton KB8KPJ, 614-846-7790. E-Mail: kb8kpj@cs.com

**PA - LEWISTOWN** - Hamfest. US 522 N. Decatur Township Fire Co. Grounds. Talk-in: 146.91. JVARC and the Decatur Township Fire Co., Richard Yingling, 717-242-1882

**TX - SULPHUR SPRINGS** - Hamfest. Hopkins County ARC, Steve Heller WA0CPP, 903-945-3659. E-Mail: steve@steveheller.com Web: http://www.qsl.net/hcrc

**VA - VINTON** - Hamfest. William Byrd High School, Washington Ave. 9am-3pm. VE exams. Talk-in: 146.985 (-600) W4CA. Roanoke Valley ARC, Dave Miller 540-977-3142. E-Mail: dmiller@rev.net or Fponton@worldnet.att.com Web: http://ourworld.compuserve.com/home spages/fcupp/rvarc.htm

### AUGUST 5-6

**WA - SPOKANE** - Eastern WA Section Convention. University High School, 10212 E. 9th Ave. Sat: 9am-5pm, Sun: 8am-12pm. NW Tri-State ARO, Palouse Hills ARC, Inland Empire VHF & Spokane RA, Kamiak Butte Am. Rptr., Betsy Ashleman N7WRQ, 509-448-5821. E-Mail: n7wrq@aol.com Web: http://www.iea.com/~n7utg

### AUGUST 6

**IN - ANGOLA** - Hamfest. Land of Lakes, Bill Brown WD9DSN, 219-475-5897. E-Mail: sharon.l.brown@gte.net

**NY - FARMINGVILLE** - Hamfest. Radio Central ARC, Neil Heft KC2KY, 631-737-0019. E-Mail: nheft@attglobal.net

**VA - BERRYVILLE** - Hamfest. Clarke County Ruritan Fairgrounds. VE Exams. Talk-in: 146.82-. Shenandoah Valley ARC, Irvin Barb W4DHU, 540-955-1745. E-Mail: ibarb@visuallink.com Web: http://www.vvalley.com/svarc/hamfest

**WI - MARSHFIELD** - HAMNIC. Marshfield Area ARS, Guy Boucher KF9XX, 715-384-4323. E-Mail: guyboucher@tznet.com

### AUGUST 12

**CA - FONTANA** - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves

**IL - QUINCY** - Hamfest. Eagles Alps Grounds, 3737 N. 5th St. 8am-2pm. VEC Testing. Talk-in: 147.63/147.03. Western IL ARC, Jim Funk N9JF, 217-336-4191. E-Mail: jfunk@adams.net Web: http://www.qsl.net/w9awe

**ME - ST. ALBANS** - Hamfest. Piscataquis ARC, George Dean WA1JMM, 207-965-8864. Email: wa1jmm@midmaine.com Web: http://www.qsl.net/parc/

**NY - ROME** - Hamfest. Rome RC, Russell Schorer KB2MAS, 315-853-8739. E-Mail: w4bny@juno.com

**VT - BURLINGTON** - Hamfest. Elks Club on North Ave. 8am-3pm. VE session. Burlington ARC, Renee Berteau N1UXK, 802-893-7660. E-Mail: n1uxk@juno.com Web: http://www.together.net/~kd1r/fest00.htm

**WV - HUNTINGTON** - Hamfest. Veterans Memorial Field House, 2590 5th Ave. 8:30am-2pm. VE testing. Talk-in: 146.76-. Tri-State ARA, Dwight D. Smith, Sr. WB8JPJ, 304-522-7865. E-Mail: wb8jpj@home.com Web: www.qsl.net/tara

### AUGUST 13

**CA - GOLETA/SANTA BARBARA** - Hamfest. Santa Barbara ARC, Alan Soenke WA6VNN, 805-562-2694. E-Mail: wa6vnn@sbarc.org Web: http://www.sbarc.org

**IA - AMANA** - Hamfest. Amana Outdoor Convention Center. VE Exams. Talk-in: 146.745/.145 and 146.520. Cedar Valley ARC, Chuck Bassett N0UTS, 319-378-0448. E-Mail: n0uts@rf.org Web: http://cvarc.rf.org

**IL - PEOTONE** - Hamfest. Hamfesters Radio Club, Christine Mack K9RFY, 708-358-1786. E-Mail: christine1@mediaone.net

**IN - GREENTOWN** - Hamfest. Greentown Lions Club Fairgrounds. Kokomo & Grant County ARCs, L.B. (Nick) Nickerson KA6NQW, 765-668-4814. E-Mail: ka6nqwnick@netusa1.net Web: http://www.netusa1.net/~ka6nqwnick/hamfest.html

**MA - ORANGE** - Hamfest. Mohawk ARC, John Dould AE1B, 978-249-5905. E-Mail: ae1b@gis.net

**MI - JACKSON** - Hamfest. Jackson Community College. VE testing. Cascade ARS, Dennis Byrne KC8IJZ, 517-522-4058 or 517-796-6966. E-Mail: byrneda@voyager.net Web: http://www.qsl.net/cars-jxn

**MN - ST. JOSEPH** - Hamfest. Del-Win Ballroom, 1985 88th Ave. 9am-2pm. VE Exams. Talk-in: 147.015(+). St. Cloud ARC, Linden Scott Hall KA0DAQ, 320-252-4498. E-Mail: lscotth@aol.com Web: http://www.w0sv.org/hamfest.html

**NJ - BAYVILLE** - Hamfest. Bayville Fire House, Rt. 9. VE Testing. Talk-in: 146.910 out, 146.310 in, PL 127.3. Jersey Shore ARS, Bob Murdock WX2NJ, 732-269-6379. E-Mail: jsarsfest@aol.com Web: http://members.aol.com/jsarsfest/jsa rsfest.html

**NY - CHEEKTOWAGO** - Hamfest. Leonard Post VFW, Walden Ave. VE Testing. Lancaster ARC, Luke Calianno N2GDU, 716-634-4667 or 716-683-8880. E-Mail: lcalianno@freewwweb.com Web: http://hamgate1.sunyerie.edu/~larc

**PA - YORK** - Hamfest. VE testing. Talk-in: 146.700. York ARC, Southern PA Comm. Group, & Hilltop Transmitting Assn., Cecil Mundorff K3DCU, 717-927-6662

### AUGUST 18-19-20

**CANADA - BC - PRINCE GEORGE** - Hamfest. Prince George ARC, Brent Lyons E-Mail: lyonsden@saintmail.net Web: http://www.pghamfest.dhs.org/

### AUGUST 19

**KS - CHANUTE** - Hamfest. Chanute Area ARC, Charlie Ward WD0AKU, 316-431-6402

**NJ - OAKLAND** - Hamfest. Ramapo Mountain ARC, Anthony Cassera N2KDZ, 914-732-2731 or 973-839-3564. E-Mail: acassera@intac.com Web: http://www.intac.com/~hansen/rmarc.htm

**WA - LONGVIEW** - Hamfest. Cowlitz County Expo Center. 9am-1pm. Talk-in: 147.26+. Lower Columbia ARA, Bob Morehouse KB7ADO, 360-425-6076. E-Mail: kb7ado@aol.com Web: http://www.qsl.net/nc7p/swapmeet.htm

### AUGUST 20

**CO - GOLDEN** - Convention. Jefferson County Fairgrounds. Denver RC, Ron Taylor K0HRT, 303-989-3978. E-Mail: k0hrt@arrl.net Web: http://www.qsl.net/w0tx

**IN - LAFAYETTE** - Hamfest. Tippecanoe County Fairgrounds. 8am-2pm. Talk-in: 147.135/443.775. Tippecanoe ARA, Bob Martin W9YE, 765-423-1035. Web: www.w9reg.org

**KY - LEXINGTON** - Hamfest. National Guard Armory, adjacent to Lexington airport. 8am-4pm. VE sessions. Talk-in 146.760-. Bluegrass ARS, John Barnes KS4GL, 606-253-1178. E-Mail: KS4GL@juno.com Web: http://www.qsl.net/k4kjg

**MA - CAMBRIDGE** - Flea at MIT. Albany and Main Sts. 9am-2pm. Talk-in: 146.52 & 449.725/444.725 W1XM/R PL 114.8 (2A). Nick Altenbernd KA1MQX, 617-253-3776 (9-5). Web: http://web.mit.edu/w1mx/www/swapfest.html

**NJ - MULLICA HILL** - Hamfest. Gloucester County ARC, Robert Budd KB2EAH, 856-358-6316. E-Mail: johovah@voicenet.com

**OH - WARREN** - Hamfest. Trumbull Campus Kent State Univ., Rt. 45 (Mahoning Ave.) and Rts. 5/82 bypass. Talk-in: 146.970, 443.000. Warren ARA, Renee McCaman KB8SVF, 330-755-2433. E-Mail: mccaman@cboss.com Web: http://www.onecom.net/wara

### AUGUST 25-26-27

**CT - ENFIELD** - Conference. Eastern VHF/UHF Society & North East Weak Signal Group, Bruce Wood N2LIV, 631-265-1015 or 631-263-9600. Email: bdwood@erols.com

**MA - BOXBOROUGH** - Convention. Holiday Inn Conference Center. Tony Penta W1ABC, 617-248-6996 or 978-887-8887. E-Mail: w1abc@arrl.net Web: http://www.boxboro.org

### AUGUST 26-27

**FL - SARASOTA** - Computer Show. Sarasota Municipal Auditorium, 801 N. Tamiami Trl. Frank Cox, 941-954-0202

**NM - RIO RANCHO** - State Convention. Rio Rancho National Guard Armory, Hwy. 550. Sat: 8am-5pm, Sun: 8am-1pm. VEC Testing. Talk-in: 145.33+ 100 Hz PL, 444.00+ 100 Hz PL. New Mexico Hamvention Committee, Marcus Lieberman KM5EH, 505-836-1724. E-Mail: km5eh@arrl.net Web: http://www.qsl.net/dchf

### AUGUST 26

**MO - COLUMBIA** - Convention. National Guard Armory, 5151 Roger Wilson Dr. 8am-2pm. VE testing. Talk-in: 146.76-. Central MO Radio Assn., Dewey Bennett WM0H, 573-445-7030. E-Mail: dbenne01@coin.org Web: http://www.qsl.net/~cmra

**TX - GAINESVILLE** - Hamfest. Gainesville Civic Center. 7am-5pm. VE Exams. Talk-in: 147.34, 443.125. Cooke County ARC, James Floyd N5ZPU, 940-668-7511. email: jfloyd@cooke.net web: http://home1.gte.net/rperkins/ccarc.htm

**WV - WESTON** - State Convention. Jackson's Mill Conference Center. 8am-11pm. VE Testing. Talk-in: 145.390/144.790. WV State AR Council, Ann Rinehart KA8ZGY, 304-768-9534. email: ka8zgy@arrl.net web: http://www.qsl.net/wvsarc

### AUGUST 27

**IL - DANVILLE** - Hamfest. Vermilion County ARA, Terry England W9CAU, 217-446-6076. E-Mail: w9cau@soltec.net Web: http://members.soltec.net/~wx9ema/VCARA/

**IL - WOODSTOCK** - Hamfest. McHenry County Fairgrounds. 6am-3pm. Talk-in: 146.52. Tri-County Radio Group, Inc., Bob Grosse N9KXG, 847-217-7052. E-Mail: n9kxg@hamfest.zzn.com Web: http://www.superhamfest.com

**IN - LA PORTE** - Hamfest. La Porte County Fairgrounds. 7am-1pm. Talk-in: 146.52, 146.61(-) PL 131.8. La Porte ARC, Neil Straub WZ9N, 219-324-7525. E-Mail: nstraub@niia.net Web: www.geocities.com/siliconvalley/byte/1653

**KS - SALINA** - State Convention. Central KS ARC, Ron Tremblay WA0PSF, 785-827-8149. E-Mail: tremblay@midusa.net Web: http://www.qsl.net/w0cy

**MI - LAPEER** - Hamfest. Lapeer County Center Bldg. 8am-4pm. VE testing. LCARA, Charles Conley N8RVG, 810-245-0347. E-Mail: cconley@bigfoot.com Web: http://www.lapeer.com/lcara

## COMPUTER SHOWS

**AGI Shows**, 317-299-8827. E-Mail: info@agishows.com http://www.agishows.com

**Blue Star Productions** 612-788-1901. http://www.supercomputersale.com

**Computers And You**, 734-283-1754. www.a1-supercomputersales.com

**Computer Central Shows** 847-412-1900 & 1-888-296-6066. E-Mail: compcent@megsinet.net www.computercentralshows.com

**Computer Country Expo** 847-662-0811 Web: www.ccxpo.com

**Five Star Productions** 810-379-3333. E-Mail: jeff@fivestar www.fivestarshows.com

**Georgia Mountain Productions** 706-838-4827. E-Mail: gamtnpro@blrg.tds.net georgiamountain.com

**Gibraltar Trade Center, Inc.** 734-287-2000. Taylor, MI. E-Mail: taylor@gibraltartrade.com www.gibraltartrade.com

**Gibraltar Trade Center, Inc.** 810-465-6440. Mt. Clemens, MI. E-Mail: mtclemens@gibraltartrade.com www.gibraltartrade.com

**KGP Productions** 1-800-631-0062, 732-297-2526. E-Mail: kgp@mail.com

**MarketPro, Inc.**, 201-825-2229. http://www.marketpro.com

**MarketPro, Inc.**, 301-984-0880. E-Mail: md@marketpro.com http://marketpro.com

**Narisaam Computer Show** 770-663-0983. E-Mail: narisaam@aol.com Web: http://www.shownsale.com

**Northern Computer Shows** 978-744-8440. E-Mail: inquiries@ncshows.com Web: ncshows.com

**Peter Trapp Computer Shows** 603-272-5008. Web: www.petertrapp.com

# Events CALENDAR

**MO - ST. CHARLES** - Hamfest. Blanchette Park. 6:30am-1pm. Talk-in: 146.670-. St. Charles ARC, Ken Fieser KB0VLN, 314-428-4383. E-Mail: kfieser@aol.com Web: http://www.qth.com/wb0hsi/
**NE - OMAHA** - Hamfest. Millard Social Hall, 10508 S. 144th St. 8am-1pm. Talk-in: 146.34/94. Ak-Sar-Ben ARC, Gerald Gross WA6POZ, 402-891-2481. Email: wa6poz@arrl.net or Ralph Erts W0SMY, email: rests@hotmail.com Web: http://www.qsl.net/k0usa
**NY - YONKERS** - Hamfest. Saunders High School, 145 Palmer Rd. 8:30am-2pm. VE testing. Talk-in: 146.265/865. Yonkers ARC, John, 914-963-1021; Paul, 914-237-5589; Dan, 914-667-0587. E-Mail: w2yrc@hotmail.com
**PA - NEW KENSINGTON** - Hamfest. Skyview Radio Society, Robert Livrone N3WAV, 724-339-9607. E-Mail: n3wav@arrl.net
**TN - LEBANON** - Hamfest. Short Mountain Repeater Club, Patsy Pierce K3PAT, 615-395-4488. E-Mail: kq4an@aol.com

## SEPTEMBER 2000

### SEPTEMBER 2

**CANADA - ONTARIO - CARP** - Hamfest. Carp Agricultural Fairgrounds, 3970 Carp Rd. 10am-1pm. Talk-in: VE2CRA 146.940-. The Ottawa ARC, Inc., Greg Danylchenko VE3YTZ, 613-236-9291. E-Mail: fleamarket@oarc.net Web: http://oarc.net/fleamarket
**TX - SULPHUR SPRINGS** - Hamfest. Hopkins County ARC, Steve Heller WA0CPP, 903-945-3659. E-Mail: steve@steveheller.com Web: http://www.qsl.net/hcrc

### SEPTEMBER 2-3

**NC - SHELBY** - Hamfest. Cleveland County Fairgrounds, US Hwy. 74. Shelby ARC, John Ledford W4JL, 704-482-4507. E-Mail: w4jl@shelby.net Web: http://www.shelby.net/n4fan

### SEPTEMBER 8-9

**AR - MENA** - Hamfest. Queen Wilhelmina Hamfest Assn., Charlotte Lee KC5DOR, 870-642-7656 or 870-642-2234 ext. 107. Email: cbee48@iwon.com

### SEPTEMBER 9

**CA - FONTANA** - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves
**IN - SPENCER** - Hamfest. Owen County ARA, Kathryn Smith K9INU, 812-829-2140
**KY - LOUISVILLE** - State Convention. Bullitt County Fairgrounds. 8am-5pm. FCC exams. Greater Louisville Hamfest Assn., Herbert Rowe W4WQD, 812-294-4905. E-Mail: wd4ixl@juno.com Web: http://www.thepoint.net/~glha/
**MI - GRAYLING** - Hamfest. Hanson Hills Recreation Area, 7601 Old Lake Rd. 8am-12pm. VE Testing. Talk-in: 145.13. ARA of Hansen Hills, John Schultz N8YSS, 517-348-4966. E-Mail: jschultz@i2k.net Web: http://www.arahh.org/swapshop.html
**MN - RUSH CITY** - Hamfest. East Central MN ARC, Larry Jilek KA0MEN, 320-358-4205. E-Mail: lj@ecenet.com
**NY - BALLSTON SPA** - Hamfest. Saratoga County Fairgrounds. 7am-3pm. VE Testing. Talk-in: 146.40/147.00 and 147.84/147.24. Saratoga County RACES Assn., Inc., Darlene Lake N2XQG, 518-587-2385. E-Mail: lake@capital.net Web: http://www.capital.net/users/lake

### SEPTEMBER 9-10

**FL - MELBOURNE** - Hamfest. Platinum Coast ARS, Tim Madden KI4TG, 321-724-9339. E-Mail: hamfest@pcars.org

### SEPTEMBER 10

**MA - SOUTH DARTMOUTH** - Hamfest. Southeastern MA ARA, Bill Miller K1IBR, 508-996-2969. E-Mail: billmiller@netzero.net
**NY - BETHPAGE** - Hamfest. Briarcliffe College, 1055 Stewart Ave. 8:30am-2pm. VE testing. Talk-in: W2VL 146.85 repeater (136.5 PL). Long Island Mobile ARC, Ed Muro KC2AYC, 516-520-9311. E-Mail: hamfest@limarc.org Web: http://www.limarc.org
**PA - BUTLER** - Hamfest. Butler Farm Show Grounds. Talk-in: 147.360 +600. Butler County ARA, Gerald Wetzel, W3DMB, 724-282-6777. Email: w3dmb@arrl.net Web: http://www.cfcorp.com/bcara/

### SEPTEMBER 15-16-17

**IL - PEORIA** - Hamfest. Exposition Gardens. 6am-4pm. FCC Exams. Talk-in: 147.075+, 53.990 (-1.7), and 146.76(-). Peoria Area ARC, Ron Morgan KB9NW, 309-692-3378 or 309-694-2469. E-Mail: kb9nw@juno.com Web: http://www.w9uvi.org

### SEPTEMBER 16

**AR - LITTLE ROCK** - Hamfest. North Little Rock Community Center, 2700 North Willow St. Talk-in: 146.940-, 444.200+ (114.8 PL). CAREN, Scott Derden K5SCD, 501-258-1881. E-Mail: k5scd@arrl.net Web: http://carenclub.webjump.com
**CA - SANTA ROSA** - Hamfest. Lewis Adult Education Center, Corner of Lewis Rd. and Lomitas Ave. VE Session. Sonoma County RAs, Inc., Rick Reiner K6ZWB, 707-575-4455. Web: http://www.cdsl.net/scra/
**GA - DALLAS** - Hamfest. Paulding Meadows Park. 8am-2pm. Talk-in: 146.895+ 77Hz, 224.700-. Paulding County ARC, Inc., Bill Houston WD4LUQ, 770-445-9191. E-Mail: Bhouston@worldnet.att.net Web: http://www.pauldingarc.com/
**IL - ROLLING MEADOWS** - Convention. Holiday Inn Holidome, 3405 Algonquin Rd. Northern IL DX Assn., Bill Smith W9VA, 847-945-1564. Email: w9va@aol.com Web: http://www.qth.com/w9dxcc
**MI - GRAND RAPIDS/CALEDONIA** - Hamfest. 9757 Duncan Lk. Ave. 8am-1pm. VE Exams. Talk-in: 147.260/R, CTCSS 94.8 Hz or 146.52 simplex. Grand Rapids ARA, Lowell ARC, & MI ARA, Lee Burgess W8MLB, 616-458-9297. E-Mail: hamfest@w8dc.org Web: http://www.w8dc.org
**NY - WHITE PLAINS** - Hudson Division Convention. Westchester County Center. 8am-2pm. Talk-in: 147.06 PL 114.8. Westchester Emergency Communications Assn., Thomas Raffaelli WB2NHC, 914-741-6606. E-Mail: wb2nhc@weca.org Web: http://www.hudsonconvention.org
**PA - SCHNECKSVILLE** - Hamfest. Schnecksville Fire Dept. Talk-in: 146.70 (PL151.4)/R, 444.90 (PL151.4)/R. The Delaware Lehigh ARC, Inc., Carl Seier, 610-261-0403. E-Mail: aa3ix@arrl.net Web: http://www.kutztown.edu/faculty/chuk/dlarc/

### SEPTEMBER 16-17

**AK - ANCHORAGE** - State Convention. Anchorage ARC, John Bury KL7QZ, 907-349-8754. E-Mail: bury@gci.net Web: http://kl7aa.akconnect.com
**PA - YORK** - Hamfest. York Hamfest Foundation, John Shaffer W3SST, 717-764-8193 or 717-764-

4805. E-Mail: w3sst@yorkhamfest.org
Web: http://www.yorkhamfest.org

**SEPTEMBER 17**

**CT - NEWTOWN** - Hamfest. Edmond Town Hall, Rt. 6. 9am-2pm. Talk-in: 146.67(-) PL 100. Candlewood ARA, Seab Lyon AA1MY, 914-831-3124. E-Mail: sslyon@att.net

**MA - CAMBRIDGE** - Flea at MIT. Albany and Main Sts. 9am-2pm. Talk-in: 146.52 & 449.725/444.725 W1XM/R PL 114.8 (2A). Nick Altenbernd KA1MQX, 617-253-3776 (9-5). Web: http://web.mit.edu/w1mx/www/swapfest.html

**OH - CINCINNATI** - Hamfest. Kolping Center. 8am-4pm. VE exams. Talk-in: 146.88-. Greater Cincinnati ARA, Jim Weaver K8JE, 513-459-0142. E-Mail: k8je@arrl.net

**PA - YORK** - Hamfest. York County Vo-Tech School. VEC testing. York Hamfest Foundation, 717-764-8193. E-Mail: w3sst@yorkhamfest.org
Web: http://www.yorkhamfest.org

**SEPTEMBER 23**

**NY - HAMBURG** - Western NY ARRL Section Convention. Erie County Fairgrounds, Rt. 62. 8:30am-4:30pm. Harold Smith K2HC, 716-424-7184 E-Mail: info@buffalohamfest.org
Web: http://www.buffalohamfest.org

**NY - MARGARETVILLE** - Hamfest. Behind the A&P. VE Exams. Talk-in: 146.520 simplex, 146.985-, 449.125-. Margaretville ARC, Lester Bourke KB2DCE, 914-586-3186 or 914-586-2324.
E-Mail: bourke@catskill.net
Web: http://www.catskill.net/marc

**TX - WEBSTER** - Hamfest. Webster Civic Center. 8am-3pm. Talk-in: 442.750+, 146.64-. Clear Lake ARC, Kyle Swarts KD5HQD, 713-666-5854.
E-Mail: kd5hqd@mindspring.com
Web: http://www.clarc.org/swapfest.htm

**WA - WALLA WALLA** - Hamfest. Walla Walla ARC, Mary Hayter KC7PNE, 509-522-5227.
E-Mail: kk7sr@arrl.net

**SEPTEMBER 23-24**

**IL - GRAYSLAKE** - Hamfest. Lake County Fairgrounds, Rts. 45 & 120. Sat: 8am-4pm, Sun: 8am-3pm. VEC Testing. Talk-in: 146.16/76 MHz (107.2 Hz PL). Chicago FM Club, Mike Brost WA9FTS, 708-457-0966. E-Mail: mbrost@cin.net
Web: http://www.chicagofmclub.org

**VA - VIRGINIA BEACH** - Roanoke Division Convention. Virginia Beach Pavilion. Sat: 9am-5pm, Sun: 9am-4pm. Talk-in: 146.970. Tidewater Radio Conventions, Art Thiemens AA4AT, 757-484-2857. E-Mail: aa4at@arrl.net
Web: http://www.vahamfest.com

**SEPTEMBER 24**

**FL - NEW PORT RICHEY** - Hamfest. New Port Richey Recreational Center, 6630 Van Buren Rd. 9am-3pm. Suncoast ARC, Ron Wright N9EE, 727-376-6575. E-Mail: n9ee@akos.net

**MD - BOWIE** - Hamfest. Prince George's Stadium. VEC testing. Talk-in: 147.105, 146.529. FAR, Dan Blasberg KA8YPY, 301-345-7381,
E-Mail: Blasberg@Bellatlantic.net
Web: http://www.amateurradio-far.org

**NY - YONKERS** - Flea Market. Lincoln High School, Kneeland Ave. 9am-3pm. VE Exams. Talk-in: 440.425 PL 156.7, 223.760 PL 67.0, 146.910, 443.350 PL 156.7. Metro 70cm Network, Otto Supliski WB2SLQ, 914-969-1053.
E-Mail: wb2slq@juno.com
Web: http://www.metro70cmnetwork.com

**OH - CLEVELAND** - Hamfest. 8am-2pm. VE exams. Talk-in: 146.73/R PL 110.9. Hamfest Assn. of Cleveland, Ron Nichols N8LZA, 1-800-CLE-FEST or 216-999-7388.
E-Mail: info@hac.org Web: http://www.hac.org

**SEPTEMBER 29-30**

**PA - TREVOSE** - Convention. Mt. Airy VHF Radio Club, John Sortor KB3XG, 610-584-2489.
E-Mail: johnkb3xg@aol.com
Web: http://www.ij.net/packrats

**SEPTEMBER 30**

**NY - HORSEHEADS** - Hamfest. Chemung County Fairgrounds. 6am-3pm. FCC exams. Talk-in: 146.70- 444.20. ARAST, Dave Lewis, 607-589-7636. E-Mail: info@arast.org, hamfest@arast.org, or winterfest@arast.org

**SD - SIOUX FALLS** - Hamfest. Old National Guard Armory, Sioux Empire Fairgrounds. VE Testing. Talk-in: 146.895. Sioux Empire ARC, Will Gravning KE0Z, 605-647-2606. E-Mail: gravning@iw.net Web: http://www.qsl.net/w0zwy

## OCTOBER 2000

**OCTOBER 1**

**IA - WEST LIBERTY** - Hamfest. Muscatine County Fairgrounds. VE Exams. Talk-in: 146.31/91, 146.25/85, 146.52 local. Muscatine ARC & IA City ARC, Steve Fowler KA9AQR, 309-537-3678. E-Mail: sfowler@winco.net
Web: http://www.qsl.net/kc0aqs/hamfest.html

**IN - BEDFORD** - Hamfest. Lawrence County 4-H Fairgrounds. Hoosier Hills Ham Club, John Scheiwe KB9LTI, 812-279-0050.
E-Mail: chairman@hoosierhillshamfest.org
Web: http://www.hoosierhillshamfest.org

**PA - WRIGHTSTOWN** - Hamfest. Middletown Grange Fairgrounds, Penns Park Rd. Pack Rats, Joe Keer KU3T, E-Mail: ku3t@amsat.org Web: http://www.ij.net/packrats

**OCTOBER 6-7**

**NH - ROCHESTER** - Hamfest. Fairgrounds. Hoss Traders, Joe, 207-469-3492

**OCTOBER 6-7-8**

**AZ - SCOTTSDALE** - Southwestern Div. Convention. Scottsdale ARC, Walt Schuknecht N7IZM, 480-947-0338. E-Mail: n7izm@arrl.net

**OK - BROKEN ARROW** - Hamfest. Broken Arrow ARC, Joe Horn KC5VPO, 918-451-0028.
Web: http://www.qsl.net/w5bbs/hamfest

**OCTOBER 7**

**FL - ORLANDO** - Hamfest. Bahia Temple, 2300 Prembrook Dr. Talk-in: 147.390. Ed KY4E, 407-660-0936. E-Mail: ky4e@excite.com

**MO - WARRENSBURG** - Hamfest. Warrensburg Area ARC, Denise Haye N0PVS, 816-697-3426.
E-Mail: we0g@microlink.net
Web: http://www.call.to/waarci

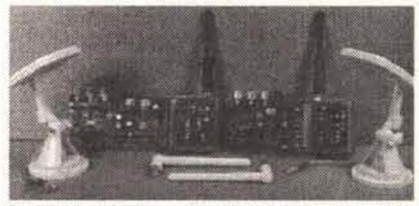
**NJ - TEANECK** - Hamfest. Fairleigh Dickinson University. 8am-2pm. FCC Exams. Talk-in: 146.19/79 and 146.52 simplex. Bergen ARA, Jim Joyce K2ZO, 201-664-6725.
E-Mail: jjjoyce@cybernex.net
Web: http://www.bara.org

**OCTOBER 8**

**CT - WALLINGFORD** - State Convention. Mountainside Special Event Facility. 9am-3pm. Talk-in: 147.36/96. Nutmeg Hamfest Alliance, Gordon Barker K1BIY, 860-342-3258. E-Mail: k1biy@juno.com
Web: http://www.qsl.net/nutmeghamfest

**MI - DIMONDALE** - Hamfest. The Summit, 9410 Davis Hwy. 8am-2pm. VE testing. Talk-in: 145.390 (-600) and 146.520. Central MI ARC & Lansing Civil Defense Repeater Assn., J. Ervin Bates W8ERV, 517-676-2710. E-Mail: w8erv@arrl.net
Web: http://www.qsl.net/CMARC/hamfair.html

## HAM GEAR FOR SALE



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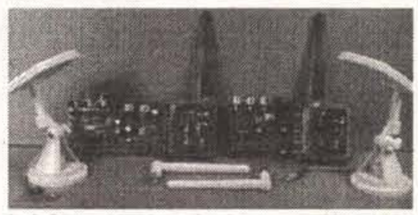

**1.2GHz ATV — 8 channel TRANSMITTERS and RECEIVERS**. 75mW output power, 1 video channel, 2 audio. SMA connectors. NTSC/PAL compatible. Includes 1/4 wave rubber duck antenna. Standard frequencies are: 1250, 1255, 1260, 1265, 1270, 1275, 1280, 1290 MHz. Custom frequencies are available. **$79/each for transmitter. $79/each for receiver**. Seabrook, 972-480-0060 (Texas, 9-6PM CST). E-Mail: main@480i.com Web: www.480i.com

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**WANTED: ROCKWELL**-Collins HF-80 equipment, 851S-1, 237B-3 log periodic, Collins literature. Jim Stitzinger 805-259-2011, 805-259-3830 (fax), bfl-jfs@smartlink.net

## HAM GEAR WANTED

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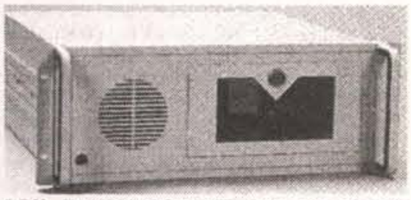

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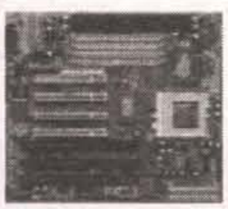

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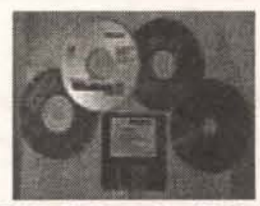

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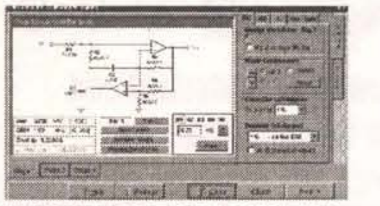

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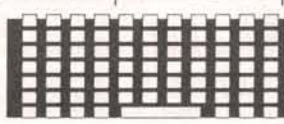

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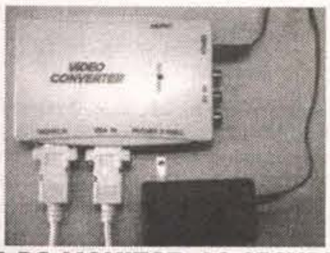

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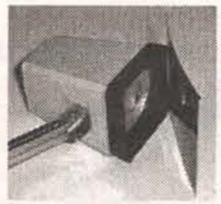

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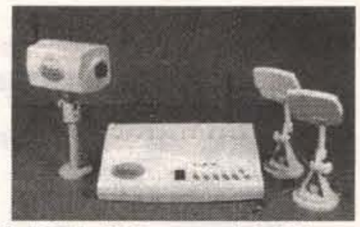

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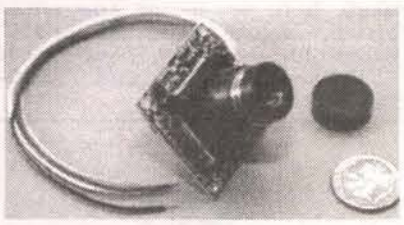

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## Doppler Direction Finder

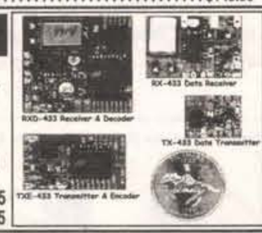
Track down jammers and hidden transmitters with ease! This is the famous WA2EBY DF'er featured in April 99 QST. Shows direct bearing to transmitter on compass style LED display, easy to hook up to any FM receiver. The transmitter - the object of your DF'ing - need not be FM, it can be AM, FM or CW. Easily connects to receiver's speaker jack and antenna, unit runs on 12 VDC. We even include 4 handy home-brew "mag mount" antennas and cable for quick set up and operation! Whips can be cut and optimized for any frequency from 130-1000 MHz. Track down that jammer, win that fox hunt, zero in on that downed Cessna - this is an easy to build, reliable kit that compares most favorably to commercial units costing upwards of $1000.00! This is a neat kit!!

**DDF-1, Doppler Direction Finder Kit .......... $149.95**

## Wireless RF Data Link Modules

RF link boards are perfect for any wireless control application; alarms, data transmission, electronic monitoring...you name it. Very stable SAW resonator transmitter, crystal controlled receiver - no frequency drift! Range up to 600 feet, license free 433 MHz band. Encoder/decoder units have 12 bit Holtek HT-12 series chips allowing multiple units all individually addressable, see web site for full details. Super small size - that's a quarter in the picture! Run on 3-12 VDC. Fully wired and tested, ready to go and easy to use!

**RX-433 Data Receiver.......... $16.95 TX-433 Data Transmitter.......... $14.95**
**RXD-433 Receiver/Decoder..... $21.95 TXE-433 Transmitter/Encoder..... $19.95**




## World's Smallest TV Transmitters

We call them the 'Cubes'.... Perfect video transmission from a transmitter you can hide under a quarter and only as thick as a stack of four pennies - that's a nickel in the picture! Transmits color or B&W with fantastic quality - almost like a direct wired connection to any TV tuned to cable channel 59. Crystal controlled for no frequency drift with performance that equals models that cost hundreds more! Basic 20 mW model transmits up to 300' while the high power 100 mW unit goes up to 1/4 mile. Their very light weight and size make them ideal for balloon and rocket launches, R/C models, robots - you name it! Units run on 9 volts and hook-up to most any CCD camera or standard video source. In fact, all of our cameras have been tested to mate perfectly with our Cubes and work great. Fully assembled - just hook-up power and you're on the air! One customer even put one on his dog!

**C-2000, Basic Video Transmitter.......... $89.95 C-2001, High Power Video Transmitter... $179.95**

## CCD Video Cameras

Top quality Japanese Class 'A' CCD array, over 440 line line resolution, not the off-spec arrays that are found on many other cameras. Don't be fooled by the cheap CMOS single chip cameras which have 1/2 the resolution, 1/4 the light sensitivity and draw over twice the current! The black & white models are also super IR (Infra-Red) sensitive. Add our invisible to the eye, IR-1 illuminator kit to see in the dark! Color camera has Auto gain, white balance, Back Light Compensation and DSP! Available with Wide-angle (80º) or super slim Pin-hole style lens. Run on 9 VDC, standard 1 volt p-p video. Use our transmitters for wireless transmission to TV set, or add our IB-1 Interface board kit for super easy direct wire hook-up to any Video monitor, VCR or TV with A/V input. Fully assembled, with pre-wired connector.

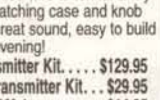
**CCDWA-2, B&W CCD Camera, wide-angle lens ..... $69.95**
**CCDPH-2, B&W CCD Camera, slim fit pin-hole lens.. $69.95**
**CCDCC-1, Color CCD Camera, wide-angle lens .... $129.95**
**IR-1, IR Illuminator Kit for B&W cameras .......... $24.95**
**IB-1, Interface Board Kit .......... $14.95**

## AM Radio Transmitter

Operates in standard AM broadcast band. Pro version, AM-25, is synthesized for stable, no-drift frequency and is setable for high power output where regulations allow, typical range of 1-2 miles. Entry-level AM-1 is tunable, runs FCC maximum 100 mW, range 1/4 mile. Both accept line-level inputs from tape decks, CD players or mike mixers, run on 12 volts DC. Pro AM-25 includes AC power adapter, matching case and bottom loaded wire antenna. Entry-level AM-1 has an available matching case and knob set that dresses up the unit. Great sound, easy to build - you can be on the air in an evening!

**AM-25, Professional AM Transmitter Kit..... $129.95**
**AM-1, Entry level AM Radio Transmitter Kit... $29.95**
**CAM, Matching Case Set for AM-1.......... $14.95**

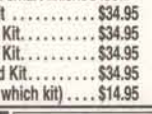
## Mini Radio Receivers



Imagine the fun of tuning into aircraft a hundred miles away, the local police/fire department, ham operators, or how about Radio Moscow or the BBC in London? Now imagine doing this on a little radio you built yourself - in just an evening! These popular little receivers are the nuts for catching all the action on the local ham, aircraft, standard FM broadcast radio, shortwave or WWV National Time Standard radio bands. Pick the receiver of your choice, each easy to build, sensitive receiver has plenty of crystal clear audio to drive any speaker or earphone. Easy one evening assembly, run on 9 volt battery, all have squelch except for shortwave and FM broadcast receiver which has subcarrier output for hook-up to our SCA adapter. The SCA-1 will tune in commercial-free music and other 'hidden' special services when connected to FM receiver. Add our snazzy matching case and knob set for that smart finished look!

**AR-1, Airband 108-136 MHz Kit.......... $29.95**
**HFRC-1, WWV 10 MHz (crystal controlled) Kit..... $34.95**
**FR-1, FM Broadcast Band 88-108 MHz Kit.......... $24.95**
**SR-1, Shortwave 4-11 MHz Band Kit .......... $29.95**
**SCA-1 SCA Subcarrier Adapter kit for FM radio.... $27.95**
**FR-6, 6 Meter FM Ham Band Kit .......... $34.95**
**FR-10, 10 Meter FM Ham Band Kit.......... $34.95**
**FR-146, 2 Meter FM Ham Band Kit.......... $34.95**
**FR-220, 220 MHz FM Ham Band Kit.......... $34.95**
**Matching Case Set (specify for which kit) .... $14.95**

## PIC-Pro Pic Chip Programmer



Easy to use programmer for the PIC16C84, 16F84, 16F83 microcontrollers by Microchip. All software - editor, assembler, run and program - as well as free updates available on Ramsey download site! This is the popular unit designed by Michael Covington and featured in Electronics Now, September 1998. Connects to your parallel port and includes the great looking matching case, knob set and AC power supply. Start programming those really neat microcontrollers now...order your PICPRO today!

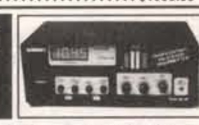
**PIC-1, PICPRO PIC Chip Programmer Kit .......... $59.95**

## 1 GHz RF Signal Generator

A super price on a full featured RF signal generator! Covers 100 KHz to 999.99999 MHz in 10 Hz steps. Tons of features; calibrated AM and FM modulation, 90 front panel memories, built-in RS-232 interface, +10 to -130 dBm output and more! Fast and easy to use, its big bright vacuum florescent display can be read from anywhere on the bench and the handy 'smart-knob' has great analog feel and is intelligently enabled when entering or changing parameters in any field – a real time saver! All functions can be continuously varied without the need for a shift or second function key. In short, this is the generator you'll want on your bench, you won't find a harder working RF signal generator - and you'll save almost $3,000 over competitive units!

**RSG-1000B RF Signal Generator .......... $1995.00**

## Super Pro FM Stereo Transmitter



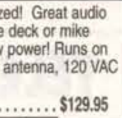
Professional synthesized FM Stereo station in easy to use, handsome cabinet. Most radio stations require a whole equipment rack to hold all the features we've packed into the FM-100. Set freq with Up/Down buttons, big LED display. Input low pass filter gives great sound (no more squeals or swishing from cheap CD inputs!) Limiters for max 'punch' in audio - without over mod, LED meters to easily set audio levels, built-in mixer with mike, line level inputs. Churches, drive-ins, schools, colleges find the FM-100 the answer to their transmitting needs, you will too. Great features, great price! Kit includes cabinet, whip antenna, 120 VAC supply. *We also offer a high power export version of the FM-100 fully assembled with one watt of RF power, for miles of program coverage. The export version can only be shipped if accompanied by a signed statement that the unit will be exported.*

**FM-100, Pro FM Stereo Transmitter Kit .......... $249.95**
**FM-100WT, Fully Wired High Power FM-100.......... $399.95**

## FM Stereo Radio Transmitters

No drift, microprocessor synthesized! Great audio quality, connect to CD player, tape deck or mike mixer and you're on-the-air. Strapable for high or low power! Runs on 12 VDC or 120 VAC. Kit includes snazzy case, whip antenna, 120 VAC power adapter - easy one evening assembly.

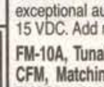
**FM-25, Synthesized Stereo Transmitter Kit .......... $129.95**



Lower cost alternative to our high performance transmitters. Great value, easily tunable, fun to build. Manual goes into great detail about antennas, range and FCC rules. Handy for sending music thru house and yard, ideal for school projects too - you'll be amazed at the exceptional audio quality! Runs on 9V battery or 5 to 15 VDC. Add matching case and whip antenna set for nice 'pro' look.

**FM-10A, Tunable FM Stereo Transmitter Kit.......... $34.95**
**CFM, Matching Case and Antenna Set .......... $14.95**
**FMAC, 12 Volt DC Wall Plug Adapter.......... $9.95**

## RF Power Booster



Add muscle to your signal, boost power up to 1 watt over a freq range of 100 KHz to over 1000 MHz! Use as a lab amp for signal generators, plus many foreign users employ the LPA-1 to boost the power of their FM transmitters, providing radio service through an entire town. Runs on 12 VDC. For a neat finished look, add the nice matching case set. Outdoor unit attaches right at the antenna for best signal - receiving or transmitting, weatherproof, too!

**LPA-1, Power Booster Amplifier Kit .......... $39.95**
**CLPA, Matching Case Set for LPA-1 Kit.......... $14.95**
**LPA-1WT, Fully Wired LPA-1 with Case .......... $99.95**
**FMBA-1, Outdoor Mast Mount Version of LPA-1 .......... $59.95**

## FM Station Antennas

For maximum performance, a good antenna is needed. Choose our very popular dipole kit or the Comet, a factory made 5/8 wave colinear model with 3.4 dB gain. Both work great with any FM receiver or transmitter.

**TM-100, FM Antenna Kit.......... $39.95**
**FMA-200, Vertical Antenna .......... $114.95**

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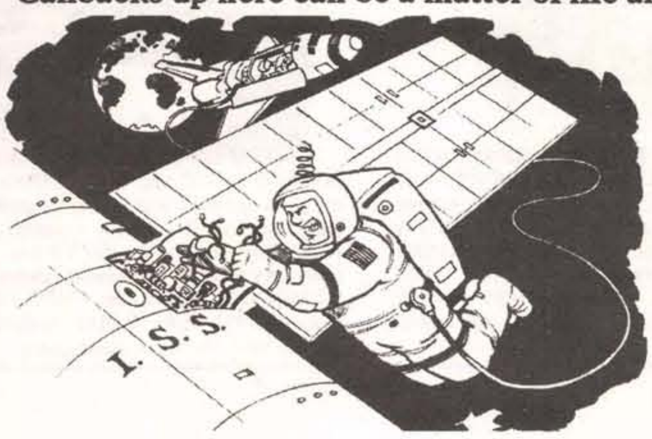
## Callbacks up here can be a matter of life and death.

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Check www.eds-inc.com/88users.html for actual users' comments as they compare their own *CapAnalyzer* to the "wizards" and "z-meters" they already own. No unsoldering to check out-of-circuit, no mistaking a shorted or leaky cap as good, as other "ESR" meters do, no guessing about whether a value is good or bad. With the exclusive three-color comparison chart right on the front panel, auto-discharge, multi-beep alert, and one-handed tweezer test probe, even your grandmother could find defective caps in that problem PWM power supply, TV, computer monitor, VCR, or industrial control board in just seconds. And because it's handheld you can service anything anywhere. It's no wonder that almost 60% of *CapAnalyzer* sales are by referrals, or service managers buying additional units. In fact, our distributors tell us it's the most asked-for-by-name piece of test equipment they sell.

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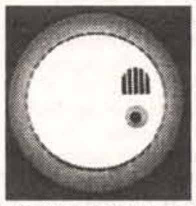
**SEE ADMART SECTION,** pages 76 and 77 for other MATCO products, including wireless systems.



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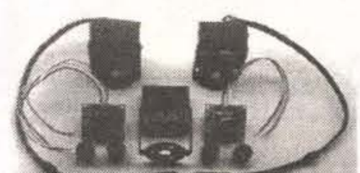
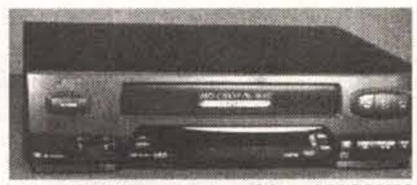


**COLOR — LOW LIGHT 2 LUX** CCD pin hole and standard lens available, only 1.37" x 1.37". **$109** each, enclosure $10 extra. Sony sensor. Matco, Inc., 1-800-719-9605 Fax: 630-350-9546. E-Mail: nsales@mat-co.com Web site www.mat-co.com



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*Continued on page 58*


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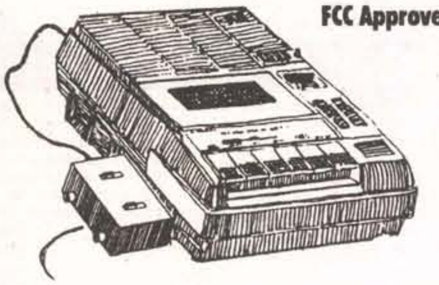

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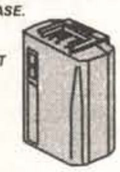

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by Gordon West

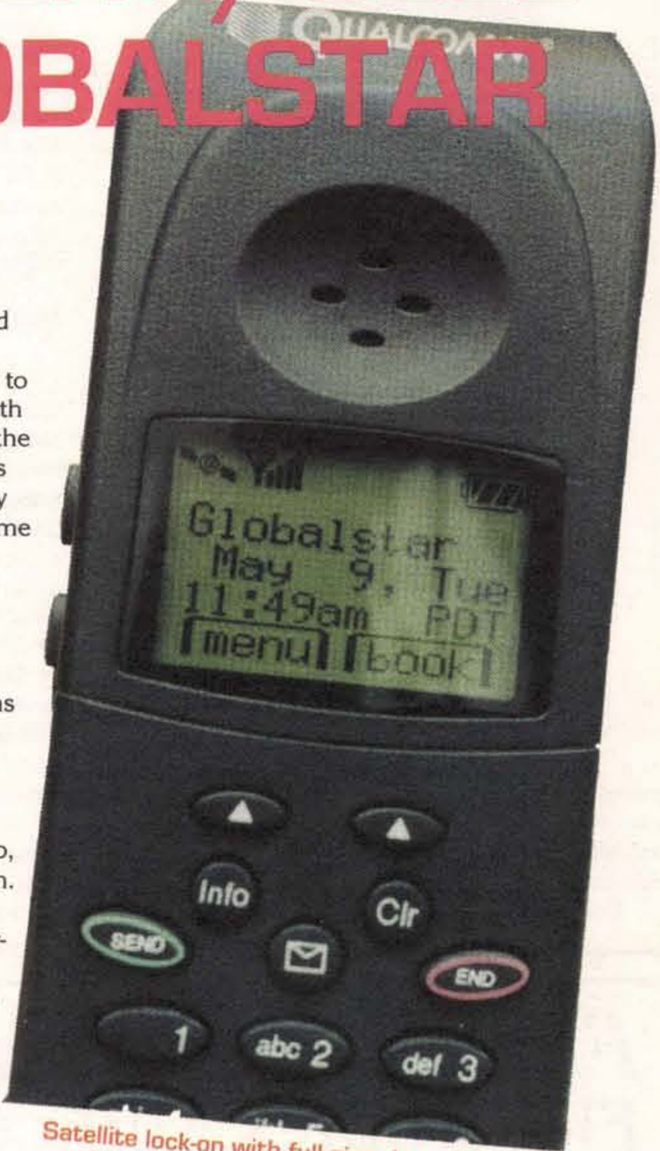
# HANDHELD SATELLITE/CELL PHONE FROM GLOBALSTAR

First, a little history is due. Everyone is talking about the apparent failure of the Iridium satellite/terrestrial portable phone system that went silent after just a few months of very unprofitable operation. I personally tested one of the Iridium phones down in Mexico; and when the satellite-based system was up, phone calls went through as advertised. There was absolutely no background hiss off the low-earth-orbit satellite connection, but I must say voice quality sounded a bit mechanical — a little bit less-natural sounding than digitized phone calls using terrestrial PCS micro cell phones.

And, the Iridium handset was anything but micro — it had an interchangeable back that housed much of the satellite transmit and receive circuitry, and it wasn't until you switched out the back with the required terrestrial cell system electronics would the Iridium phone get a bit scaled down.

But probably the biggest question about the Iridium system was exactly how much was it going to cost to make a phone call from another country, or out at sea, or within the coastal waters of our own country. Numerous phone calls to the reps for Iridium could only give us vague answers, so it may have been no wonder that travelers and mariners held up their purchase of Iridium equipment until pricing could be confirmed.

And I guess now the big question is what to do with the satellites, whizzing around the earth every 100 minutes in the "OFF" mode. With the billions spent to put all of the Iridium satellites up in their low-earth orbits, I can't believe they will all be soon relegated as space junk to come down on purpose in fireballs.



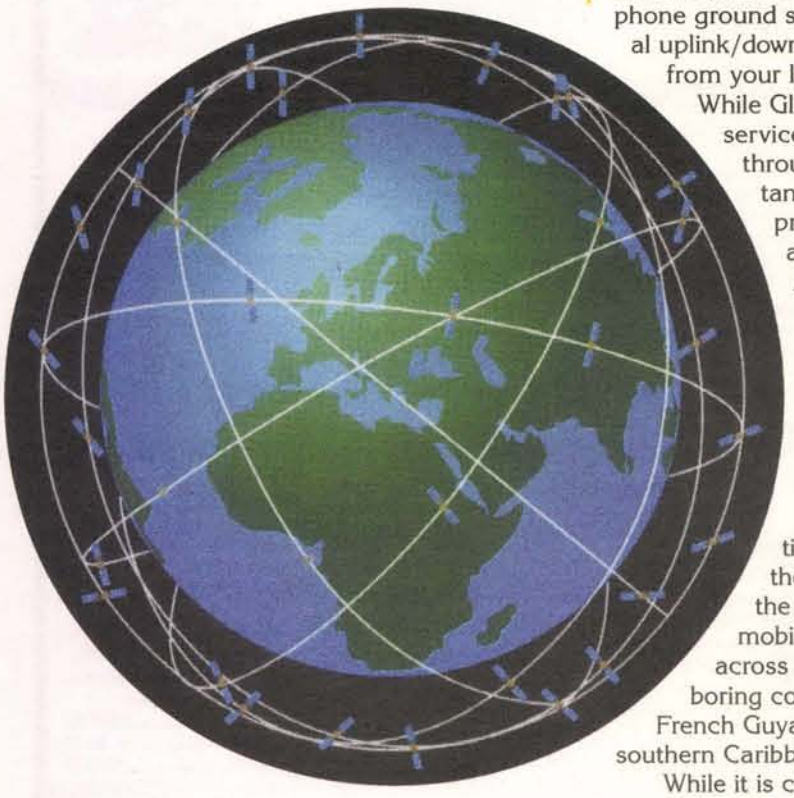
Satellite lock-on with full signal strength.

## GLOBALSTAR NOW ON THE AIR

Say who? Globalstar USA is an indirect subsidiary of Vodafone Air Touch Plc., and has exclusive rights to sell Globalstar satellite service across the continental United States. Globalstar USA owns and operates the land-based portion of the Globalstar network throughout the United States, Canada, Mexico, and — good news for mariners — the Caribbean. Globalstar is lead by founding partner Loral Space & Communications, which is a partnership of the world's leading telecommunications service providers and equipment manufacturers, including the Qualcomm handheld, satellite/terrestrial, portable phone I operated during these tests.

Just as important as the 48 low-earth-orbit satellites in space is the network of Globalstar land-based, public-switched, telephone ground stations to receive the mutual uplink/downlink "bent pipe" signal to and from your little battery-operated handheld. While Globalstar has an agreement with service providers in over 100 countries throughout the world, the all-important "mutual view" land stations presently serve North America and parts of Central and South America, as well as Europe, South Africa, and Asia. As of Feb. 2000, this gives available service to customers in 21 countries, with Globalstar planning to introduce service in more than 80 countries by mid-year.

These all-important land stations are called "gateways," and the 13th gateway just came up on the air in Venezuela, providing mobile satellite telephone service across all of Venezuela, as well as neighboring countries like Guyana, Suriname, French Guyana, and a number of French southern Caribbean islands.

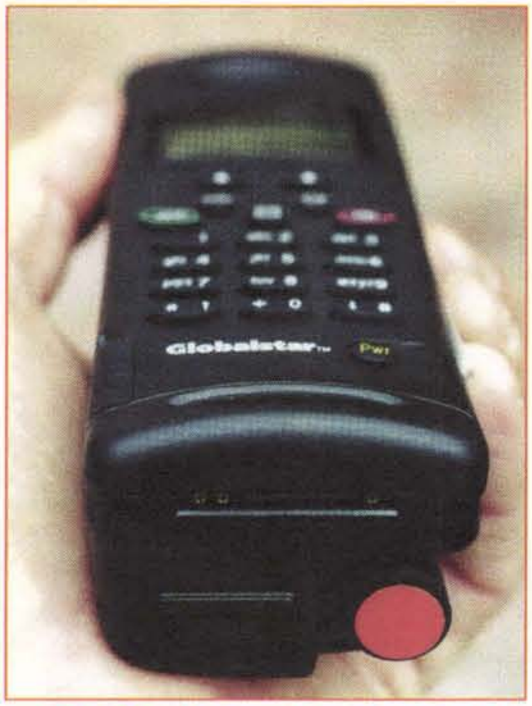

Globalstar's 48-Satellite Low Earth Orbit Constellation

While it is certainly impressive to see a global view of 48 low-earth satellites spinning around as the world turns beneath it, it doesn't mean that the Globalstar portable phone in the satellite mode will have a mutual view of the same exact satellite the land station may receive.

You may visualize the reception area of these low-earth-orbit satellites by tuning in the NASA TV channel during the next Space Shuttle and International Space Station mission. What you might see out the window of the shuttle is pretty close to the signal capture area of a low-earth-orbit satellite. At 500 miles up, the satellite could see approximately 1,700 miles to the north, 1,700 miles to the south, 1,700 miles to the east, and 1,700 miles to the west. (You can estimate distance to the horizon in miles by converting miles of altitude to feet of altitude, and then taking the square root of this for your range in miles to the visible horizon. For the radio horizon at microwave frequencies, you might add an additional 10 percent.)

**With the billions spent to put all of the Iridium satellites up in their low-earth orbits, I can't believe they will all be soon relegated as space junk to come down on purpose in fireballs.**

For sailors, 48 satellites circling the world does not mean worldwide and oceanwide complete coverage. The earth-bound gateway stations are positioned strategically to pick up the



The Qualcomm handset will soon support satellite and cell computer calls.

greatest anticipated volume of incoming signals from those areas of the world where local terrestrial cell phone coverage is either not available or simply impractical due to terrain.

For West Coast sailors, the Texas gateway station may lose a mutual view of your handheld Globalstar portable when you are beyond halfway to Hawaii.

"There is no gateway on Hawaii," comments Tom Geller, Senior Account Executive for GSI Group. "But there is plenty of blue water cruising coverage for mariners and sailors, and we invite everyone to look at our present coverage map at http://www.globalstarusa.com/h_06.shtml. We presently have 13 gateways in operation," adds Geller, indicating the enthusiastic response he recently received from boaters and sailors at a recent marine show.

## HOW GOOD?

The Qualcomm handheld phone, Model GSP1600, was an amazing piece of cellular and satellite technology — you get the works all inside this single, compact, portable, analog/digital handset. There are no bulky backs to strap on like Iridium, and no other expensive additions to buy to get the system up and running on your local analog cellular service, or your local digital cellular service, or up to a satellite using digital technology pioneered by Qualcomm. Qualcomm digital is Code Division Multiple Access (CDMA), and AMPS (Advanced Mobile Phone System) is the traditional high-fidelity analog service in the 800 MHz cellular bands.

In our local Southern California AMPS service, talk-and-listen fidelity was spectacular, and best of all, no annoying echoes or delays in the conversation. During our reviews, no one knew I was on a portable cell phone.

With the push of a button, the system can switch over to the digital network, and talk-and-listen clarity was without any background noise at all, like AMPS, but the conversation had slight delays and both my transmit and receive voice conversations sounded a bit brassy and hollow, typical of any digital cell phone system. It was tough to carry on a fast-paced conversation in the digital mode.

With one more push of a mode button, I switched over to the satellite mode and, within a couple of seconds, the little LCD readout indicated a superb satellite signal, and there was the dial tone. The dial tone sounds exactly like the dial tone in a cell phone set, and I needed to do a double-take to insure I was indeed working off of the secondary Tootsie Roll-sized satellite antenna. As soon as I put my hand around the bigger satellite antenna, I could see the signal just about disappear. Sure enough, I was indeed working off of a low-earth-orbit satellite. My phone call went through just as fast as a typical cell phone call, and there was absolutely no major delay in the conversation to what I had experienced with the old Iridium system. With Iridium, dial tones and keypad tones sounded strangely different, but with the Qualcomm Globalstar system, everything sounded just like I was going through a local cell site.

## BUT HOW LONG?

During repeated tests, we were able to get

about three and a half hours talk time in the satellite mode, with a full day of standby time waiting for an incoming phone call. In the digital mode to a local provider, we could go for almost five hours talk time, and three days standby time. In the AMPS mode, we achieved a little over two and a half hours talk time, and about 14 hours standby.

They supply a charger with a nifty retractable 110 VAC blade assembly that allows you to easily plug in and get a fast recharge. There is also an accessory 12-volt, cigarette-lighter adapter cable, too, for charging and running the equipment in your vehicle or boat.

Another one of our tests was purposely taking the equipment into an area with no cellular coverage. We would use it in the automatic mode and see whether or not it could detect cell dropout, and switch over to satellite. At the bottom of Zion Canyon, it did just that! We were amazed that we could get satellite signals so deep down in the valley. And out on the water, as soon as we cruised well beyond cellular shoreside coverage, the unit quietly switched over to the satellite mode, and didn't miss a beat!

### DATA YET?

Data capabilities are coming, up to 9.6 KBPS, including E-Mail, file transfer, FAX, and short message service. They say it's going to be the fall before the digital interconnects may take place.

### OKAY, HOW MUCH?

At last we get firm answers to this question on a satellite portable phone system! Globalstar USA offers three distinct domestic pricing plans based on a monthly service charge and fees for satellite connection and use. The basic plan is $29.99 per month, plus $1.69 per minute for gabbing offshore or way down in Mexico off of the satellite. If you do a lot of talking, another plan is $169.99 per month and includes 100 minutes of satellite air time, with each additional minute at $1.49. And if you really plan to do *a lot* of yakking off the satellite, they have another plan for $370.00 that includes 250 minutes of satellite air time, with additional minutes at $1.39. Add to these amounts your roughly $30.00 per month to subscribe to local cellular digital or analog coverage that will meet your requirements for staying in touch with this same equipment through your local cell phone provider.

The 11-ounce Qualcomm tri-mode phone has a suggested retail price of $1,500.00 and, if you want to go with a fixed satellite


One phone for satellite and earth comms.

## GLOBALSTAR NEEDS CUSTOMERS


The demise of the small Iridium satellite phone has cast a shadow on Globalstar's bid to be successful in low-earth-orbit, portable, satellite phone service. In a recent *Wallstreet Journal* report, customers may hold off going with the Globalstar system after they have heard the war stories about friends and acquaintances literally "stuck" with useless Iridium handsets.

In an interview with Antony Bruno in the April issue of *RCR*, a Globalstar spokesman, Mac Jeffery, was quoted,"...If Iridium hadn't happened, we wouldn't be having this conversation — we are paying for their sins ... "

"Analysts turned against us quick," he said. "Everything is exactly as it was before, the only factor that changed was Iridium ... Iridium really spooked people," adds Jeffery.

Analysts calculate it will take about a half-million subscribers by the end of this year to keep Globalstar looking good for continued service. Even one-quarter million subscribers could keep their future looking good. But if less than 100,000 subscribers indeed sign up for Globalstar service and take on the $1,500.00 phone, Globalstar would be well short of its projected success in this endeavor.

Chances are Globalstar users will begin to see some sort of rebates as marketing efforts get into full swing this summer. Just like Magellan Orbcomm data communicators, Orbcomm users were turned into sales personnel when Orbcomm gave away many months of free airtime to help attract new users to the system. At one point, the handset was being offered "free" for those users that would sign up for three years of monthly service.

So stay tuned into Globalstar — chances are summer specials will keep this new low-earth-orbit communications service viable and affordable, all from a little handset not much larger than a traditional cell phone.

phone set-up, you could spend up to $2,500.00 for a system aboard your yacht or major land cruiser.

## AND SPEAKING OF LAND

We also tested the Qualcomm phone in the satellite mode in hilly terrain with plenty of trees to obscure the satellite signal. Globalstar builds into their satellite system "path diversity" — a way of taking each call and carrying it by several satellites, allowing for a soft handoff in case one of the satellites loses track of your signal if you should go behind a big pine.

The new satellite maintains the transmission of the original signal to the appropriate terrestrial gateway where the call is then routed locally through terrestrial communications infrastructure. And I am told that the local gateway station with Texas as the one we were going through usually routes calls via land lines and will always try and electronically and automatically avoid sending the call back up to a geostationary satellite so as to minimize echoes and time delays. With the old Iridium system, it was cumbersome to talk through a satellite. With Globalstar, it's just like cellular!

## AND THE FUTURE IS ...

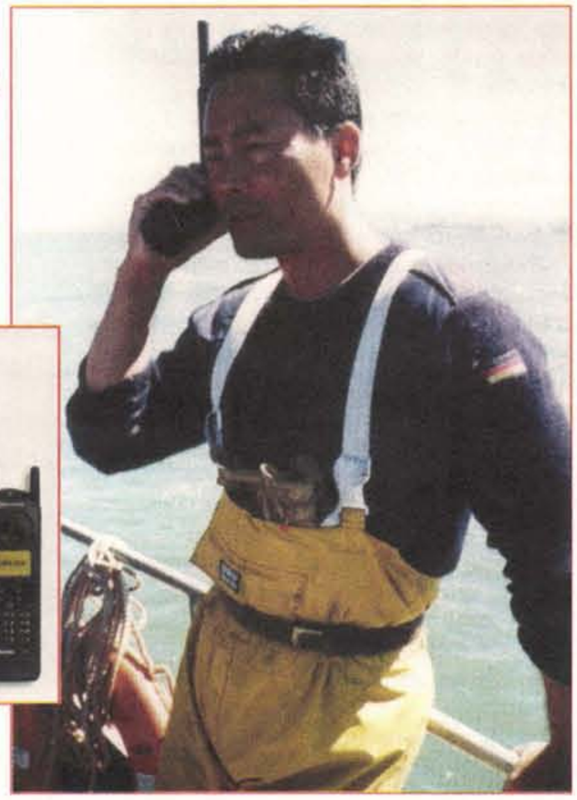
We will continue to see Globalstar work for more gateway land stations in order to expand the usable range to satellites and gateways. However, these expensive gateway stations will only go up if there is a perceived demand for service in an area presently in a shadow. A few sailors a month might not justify setting up that Hawaiian station as of yet but, if the service really takes off among mariners, we might see a Hawaii gateway in our future. Since this is a major sailing route, I would think that this system would attract plenty of new users.

Popular sailing routes will certainly attract the potential cruise line business, plus commercial freight and fishing vessels, too. Hopefully this will encourage investors to add additional gateway earth stations with a mutual view of the satellite that the sailor will see.

I believe that the user of Qualcomm's Code Division Multiple Access (CDMA) technology will continue to be a pacesetter in digital communications to come. While there is also Time Division Multiple Access (TDMA) technology out there, CDMA seems to have many strong advantages.

For our readers with technical questions, Globalstar invites everyone to log onto their web site and look at the coverage maps plus post questions about their service. A list of Globalstar dealers can be found by calling **Globalstar USA** at **1-877-SATPHONE (877-728-7466)**.

I was reluctant to give back the demonstration phone because it was so simple to operate, and un-clumsy like other satellite portable phones I had operated a few months earlier. I believe that Globalstar is here to stay and, if you are traveling within satellite coverage with mutual view of the ground stations, do consider Globalstar as a three-way phone system with great promise! **NV**



Qualcomm GSP 1600 tri-mode satellite handset.

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# A Tethered *Backyard* Explorer-Bot

**by Karl Lunt**

*Why use a wire tether? Why not use RF links?*

I've had a lot of fun recently running Tacklebot around in my backyard. Long-time readers of my past "Amateur Robotics" column will recognize Tacklebot as a machine I built using a sturdy, plastic fishing tackle box as a frame. If you haven't yet seen Tacklebot, stop by my web page at www.seanet.com/~karllunt and check it out.

Basically, Tacklebot consists of two Dayton 2L011 gearhead motors bolted to a length of 1/4-inch aluminum plate, in turn, bolted to the underside of a large tacklebox. The robot uses a large single caster up front, giving it a three-point support system. Electronics consist of a 68hc11 BOTBoard+ (BB+), a motor controller made of power MOSFETs and DPDT relays, and a National Semiconductor SimpleSwitcher® power supply board. You can find all the details of Tacklebot's construction in my book, *Build Your Own Robot!*, so I'm not going to go into a lot of detail here.

But I am going to discuss the tether I hooked to Tacklebot to give me remote control over my robotic explorer. Adding a simple tether — in the form of a long cable with suitable connectors — to an easily-constructed robot frame can give you a powerful, fun-to-run machine with little cost or work.

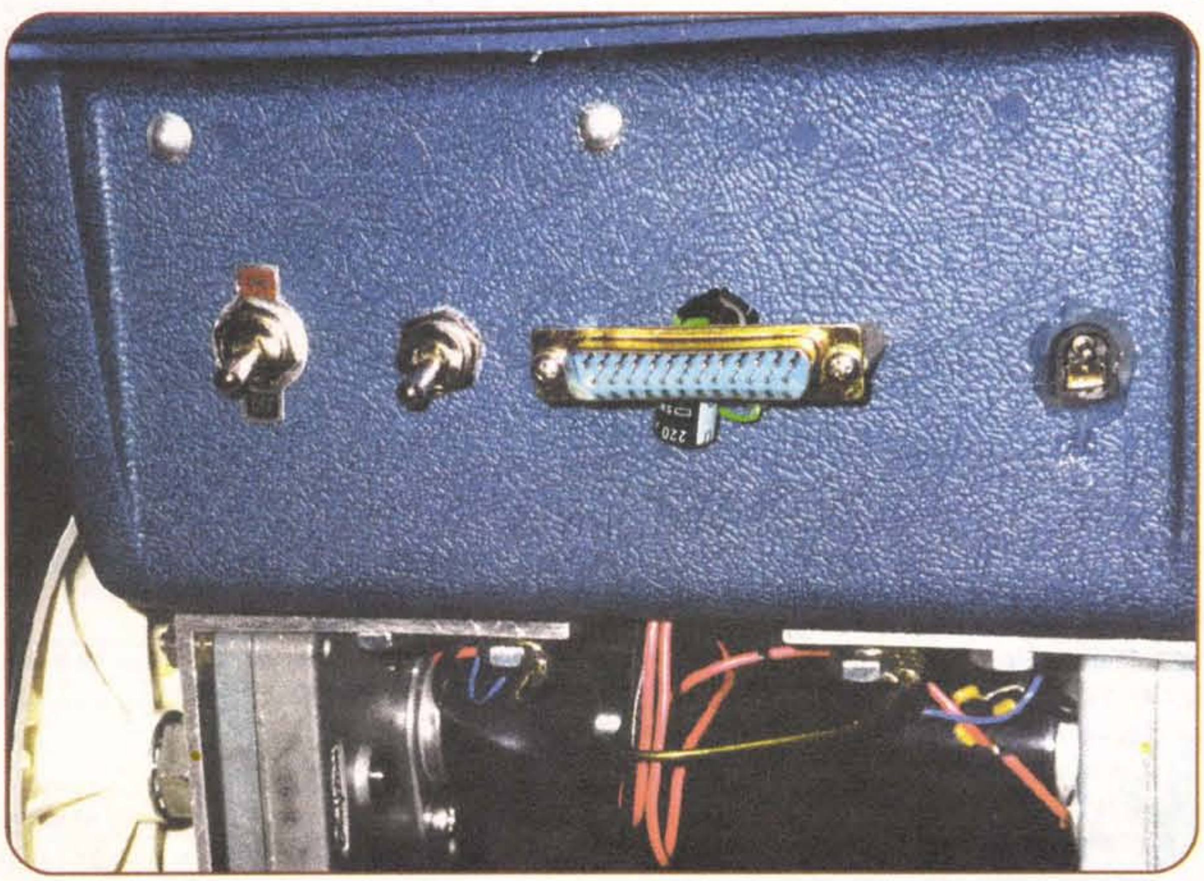
Long-time 'bot builders are probably asking, "Why use a wire tether? Why not use RF links?" A tether solves some nasty problems that crop up when you try to go wireless. First, a wire tether is simple and cheap to build. I paid $25.00 for 100 feet of flexible, tough 10-conductor shielded cable at the local surplus store. This bought me a video link, a serial communications link, and a 12 VDC power conduit. In one stroke, I eliminated two sets of RF connections and added a power link that I could never have made wireless.

A wire tether also offers a means of recovering a fallen robot that has gone someplace you can't or won't go. I ran Tacklebot into the crawlspace under my house during its testing phase, and a couple of times I had to drag the machine out by its tether when it got stuck. Sure, I could have crawled down there after it, but that's not the point. Had I been exploring a dangerous or impossibly small area, I would have had a tough time recovering my robot. In this case, a wire tether offers a big advantage over wireless links.

Finally, you can build a wire tether in just an evening or two, and spend the rest of your time playing with your robot. I've built a few wireless links in my day, and they always seem to take longer to install and cost more than I planned. They do have their purposes, but the name of the game is "play" and you can play faster by adding a wire tether. After you have played with your tethered robot for a while, you can always add wireless links later.

### Design of a wire tether

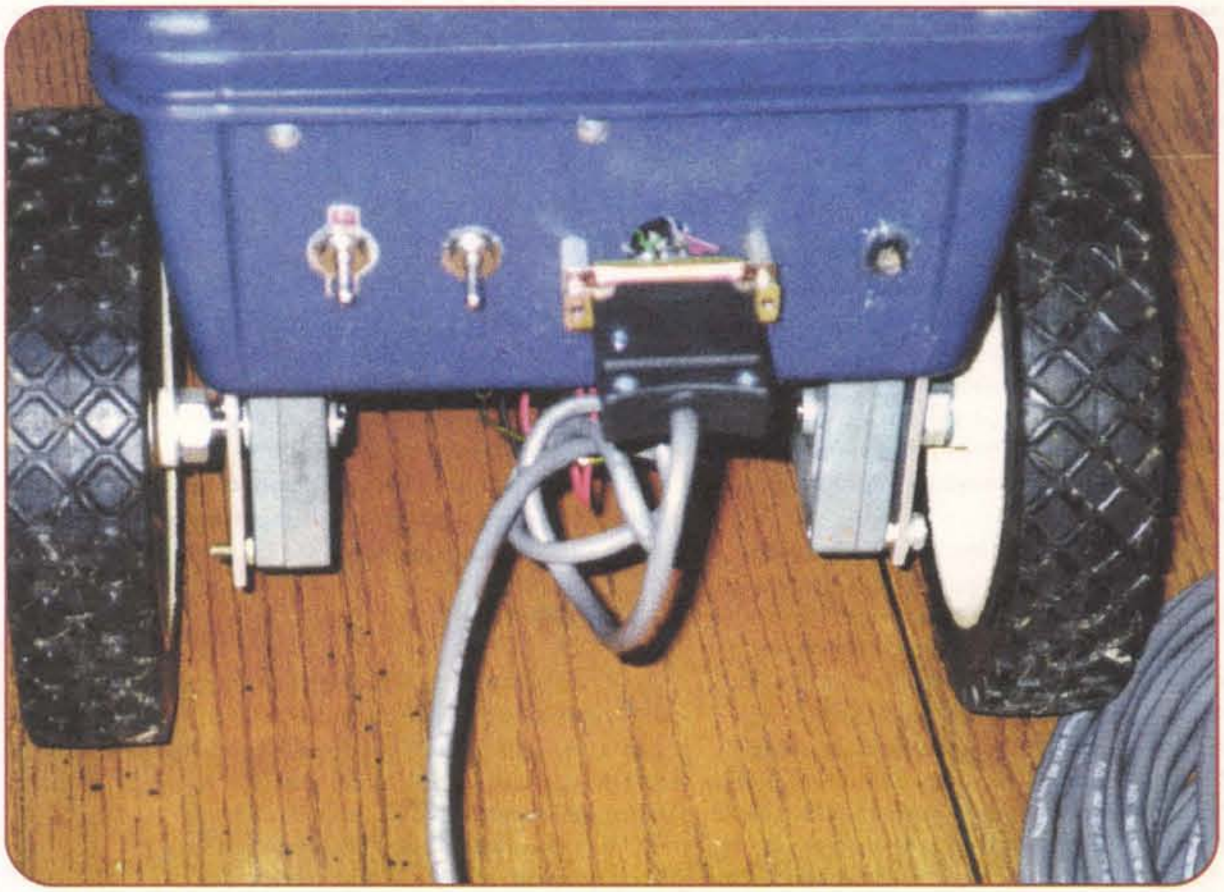
The tether I built for Tacklebot carries three signals; refer to the accompanying diagram of a wire tether design (Figure 1). The RS-232 serial link handles commands from my laptop PC and data returned by the robot. The video link hooks to a small black and white video camera mount-




**A look at Tacklebot's rear apron, showing the main power switch, motor power switch, DB-25 tether connector, and battery charger jack.**

## Ready to go!

**I've tied the tether's cable through the restraining loop underneath the robot's frame, then hooked the tether to the DB-25 connector on the rear apron. All I need now is to apply power and do some exploring.**



ed on the front edge of the robot. The 12 VDC power link provides the 120 mA of current needed by the video camera, so the camera doesn't add an extra drain on the robot's batteries.

The cable I chose for my tether contains 10 26 AWG wires and a separate drain wire with shield. I used two wires each for the 12 VDC and ground signals to make sure they had a low resistance down the 100-foot length of cable. Thus, I need a total of seven wires for my tether signals, leaving me three spares for extra features later.

I chose to terminate each end of the cable in a DB-25 connector; I put a female connector on the robot end of the cable and a male on the computer end. I realize that this connector scheme is far larger than it needs to be, but I was in a hurry and the stores were closed. I would have preferred DB-15s, but I had DB-25s laying around, so that's what I used.

When you build your cable, be sure to add good-quality hoods to the connectors at each end. These only cost a buck or so, and will protect the connections from casual moisture and physical damage. Get the hoods that provide strain relief, because the cable will get a good workout and it's a royal pain tracking down failures caused by fatigued connections.

The RS-232 signals used in the tether are your basic serial communications signals. The video signal is the NTSC video generated by the B/W camera. Normally, you would use coax for this signal, but this is a fairly short run, and I haven't seen any problems with the signal displayed on my video monitor. In fact, the security system that used this camera originally included about 60 feet of small-gauge zipcord wire for signal transmission, so I figured my cabling would be good enough.

When I first designed this tether, I had envisioned another use for the 12 VDC power link. I was going to build a simpler frame than Tacklebot; a frame consisting only of motors and electronics, but no batteries. The robot would take its motor power from the 12 VDC feed in the tether. This would let me build a much lighter, smaller frame and give me more useful power from the motors, which wouldn't have to waste so much torque lugging batteries around.

For various reasons, I had to abandon this idea and rework Tacklebot instead. But building such a frame appeals to me. It would make a great club project, and could serve as the springboard for a fully wireless robot. And you wouldn't have to bother with battery chargers, extra weight, or the added size required for those big batteries.

I used a Radio-Shack lump-in-the-line 12 VDC power supply as the source of the power feed in my tether. It is rated for an amp or so of current, well beyond the needs of my video camera. The model I'm using — 273-1653 — even includes a push-button circuit breaker on the top; this came in very handy at least once, and spared me having to replace some fried components.

### A simple pan head

Mounting a video camera on a robot lets you get a whole new view of the world. Seen from a height of about 16 inches, my backyard looks very alien and jungle-like. But driving a robot around with a camera that can only look forward can prove challenging. You can't look to the side to see how close you are to a wall or shrub, and you can't look sideways to gauge your rate of travel. Thankfully, adding a pan head to your camera takes nothing more than a


**You can reach me by E-Mail at: karllunt@seanet.com**
**Or hit my web site at: www.seanet.com/~karllunt**
**My web site also includes details on ordering my new book, *Build Your Own Robot!* (A. K. Peters, Ltd.; ISBN 1-56881-102-0; $34.00).**

hobby servo motor and some tinkering. Refer to the accompanying diagram of a simple camera pan head (Figure 2).

I started with a Futaba S-148 servo motor, available at most large hobby stores and through the mail from outlets such as Tower Hobbies. This motor provides 42 oz-inches of torque, features a compact design that is easy to mount, and uses standard servo timing pulses for control. Most of the computer boards we use in the Seattle Robotics Society, including the BB+, are already designed to control up to four of these motors, and they are a mainstay of many SRS designs.

When you buy a Futaba servo motor, you also get a package of various control horns and attachments. I started with two control horns. The 1-3/8th inch round horn, mounted on the top of the pan head, holds the bolt that threads into the mounting hole on the underside of my video camera. I drilled a suitable mounting hole on the control horn to hold this bolt. I also drilled out holes for three sets of 4-40 spacers and hardware. I then drilled matching holes in a 1-1/2 inch four-point horn so I could bolt the two horns together as shown.

Next, I put the bolt for mounting the camera into the larger hole on the round control horn, ran a nut down on it to hold the bolt firmly in place, then spun a second nut onto the bolt. Finally, I put the small servo control horn screw (not shown here) into the center mounting hole of the lower control horn. You will use this screw to fasten the pan head assembly to the servo motor shaft. Note that you can push a small Phillips screwdriver through the center of the upper control horn to reach the control horn screw; this gives you access when you need to tighten the screw to the servo shaft.

## A tether solves some nasty problems that crop up when you try to go wireless.

### Final assembly

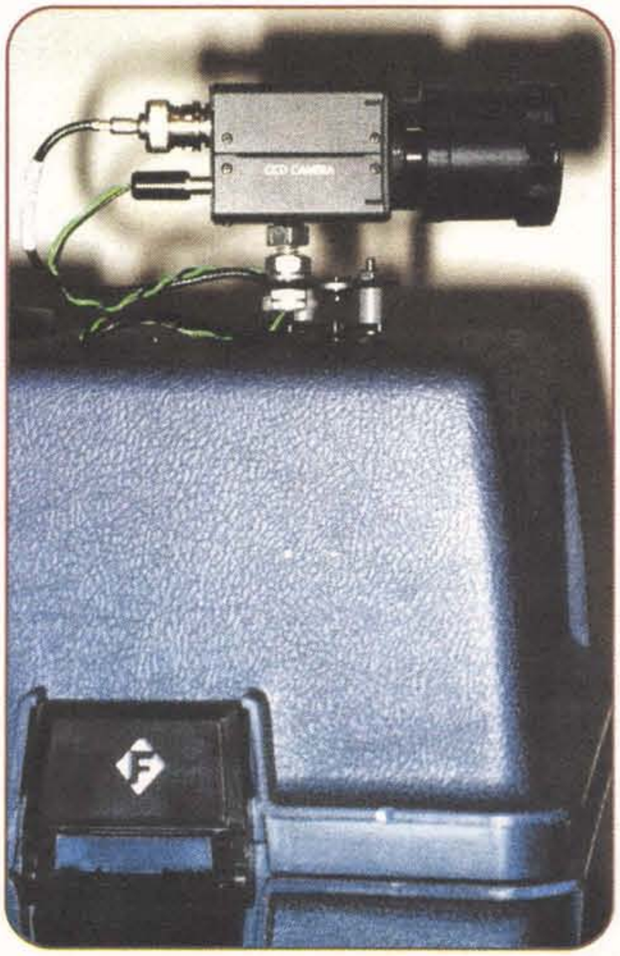
I had to do some slicing and dicing on Tacklebot's lid to make room for the pan head servo. The tacklebox is made of tough but flexible plastic, which drills easily and can, with effort, be cut with an Exacto knife. Be very careful while hacking on this plastic with a knife; you can easily slip and cut yourself.

I drilled and cut a hole for the servo motor shaft in the lid of the tacklebox, near the robot's front end. I then positioned the motor and measured for a 1/8th-inch hole on either side of the motor, near the center of the motor frame. I stuck a suitably-sized piece of double-sided foam tape to the face of the servo motor, then used these two holes for a nylon wire-tie to clamp the motor firmly to the inside lid of the tacklebox.

Mounting the tether connector to the outside rear face of the robot frame required more cutting and hacking. I drilled two holes for #4 hardware in a suitable location, then bolted the DB-25 male connector to the outside of the box, using appropriate spacers and hardware. Be sure to use wide #4 washers on the hardware that mounts to the plastic of the tacklebox, to spread the load when you tighten down the screws. This prevents the screwheads or the nuts from digging right through the plastic and popping out.

I also drilled a large hole between the DB-25 mounting holes, so I could run the wiring harness from the DB-25 connector to the inside of the box. Once I got the wiring inside, I added appropriate connectors for the various signals, then dressed them to the proper points inside the robot frame.

I knew I would eventually need to drag the robot around by this tether, and the DB-25 connectors wouldn't stand the strain. So I used a pair of heavy-jawed nippers to cut apart a stout coat hanger. I then used pliers to twist a four-



**Close-up of Tacklebot's video camera and pan head. The servo-mounted pan head and the camera's field of view combine to provide 180 degrees of coverage.**

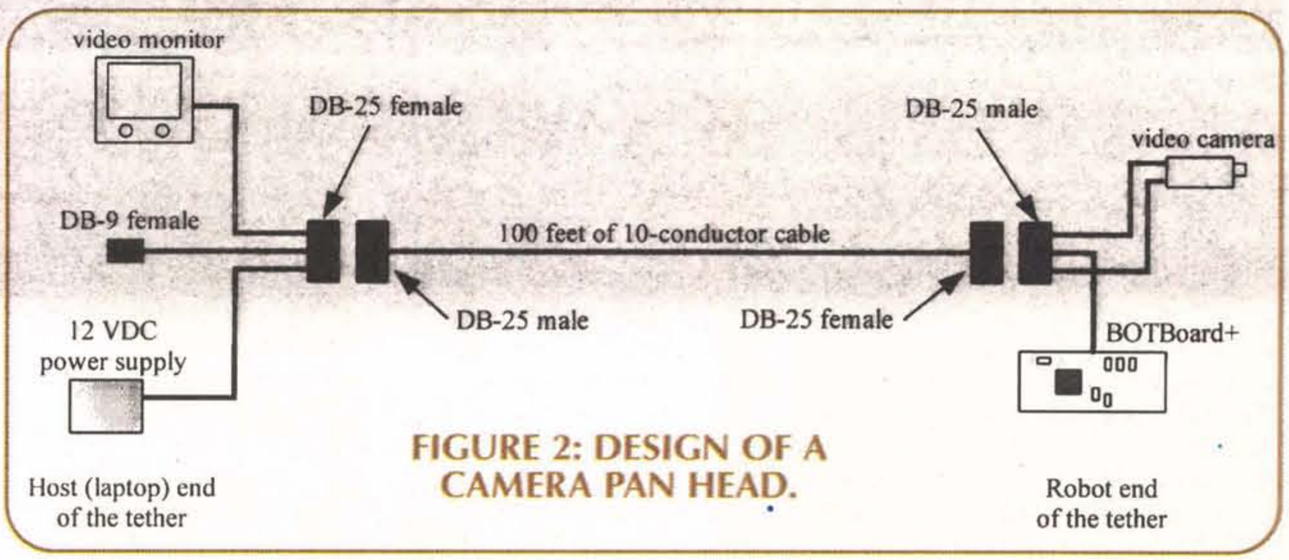



**FIGURE 2: DESIGN OF A CAMERA PAN HEAD.**

inch length of this wire into a suitable shape that I could bolt to the metal plate on Tacklebot's underside. By using the heavy bolts already holding the motors, I made a strong metal loop to which I could fasten the tether cable. I can either use a wide wire-tie to fasten the tether to the loop, or just knot the cable around the loop. Either way, I have a sturdy mechanical hook-up for the tether, which also provides strain relief for the electrical connection.

### Now, the firmware

I intended to run Tacklebot around my backyard by sending single-key commands from my laptop over the RS-232 cable. The laptop side of the equation was easy; I could just crank up that old standby, ProComm. But the robot side would require some firmware for my 68hc11 BOTBoard+, and that means SBasic.

Those of you who followed my earlier column are no doubt familiar with my SBasic compiler. It lets me write small, fast programs in a friendly dialect of Basic, without having to resort to 68hc11 assembly language. It isn't a full-featured Basic, like some of the Microsoft products, but it has plenty

You can build a wire tether in just an evening or two, and spend the rest of your time playing with your robot.

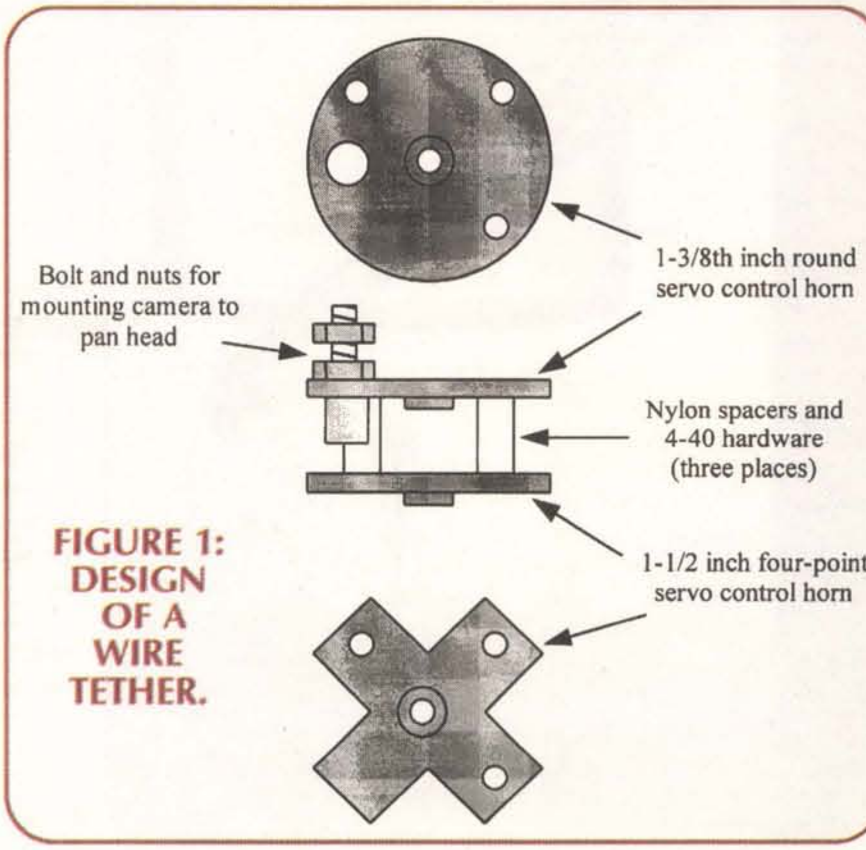
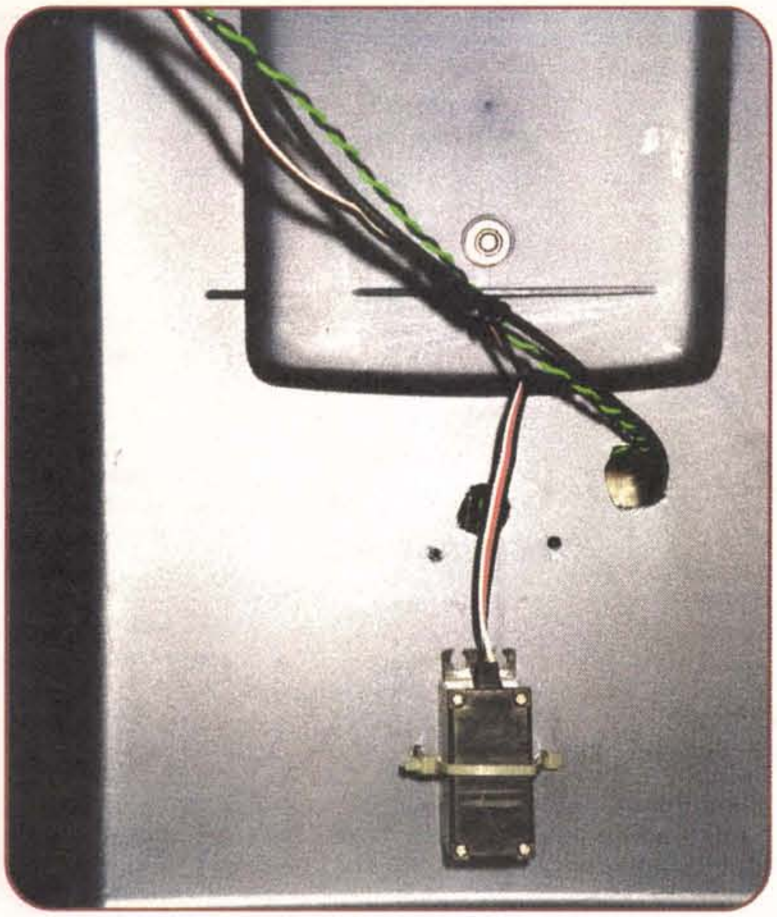



**FIGURE 1: DESIGN OF A WIRE TETHER.**



A view of the lid's inside, showing how I mounted the camera's pan head servo. The cable leading to the servo carries the control signal and 5 VDC, while the two cables going out of the lid's top carry power to the camera and return the video signal.

of power for running 'bots, and best of all, it's free. Just hit at my web site and download a copy, complete with the needed 68hc11 assembler.

The design for Tacklebot's firmware began with an earlier version of my Tacklebot firmware. I changed a few elements to give me more control over the robot's speed, and I also added commands for positioning the camera's pan head. Refer to the accompanying listing for details (Figure 3).

When the robot powers up, the firmware starts at label MAIN. After initializing the real-time interrupt (RTI) subsystem and setting up the motors, it sends a brief message to the user, then waits in a loop for the user to enter a 'G.' This prevents the robot from taking off as soon as I apply power to the motors.

Once I've entered this simple password, the firmware enters a large loop that accepts a character, tests it, and executes the appropriate command. Numbers from 1 to 7 change the position of the camera's pan head; the number 4 moves the camera to the center position. The letters r, l, f, and b let me move the robot right, left, forward, and backward. I can also enter a space to stop the robot.

Since Tacklebot can move at a pretty good clip, I also added the q and z commands to set the speed of the motors. Note that entering either letter stops the motor but sets the speed variable for the next motion command. Finally, the e and c commands turn lights on and off, though I don't actually have lights hooked up yet.

As you can see, the firmware is pretty simple, yet it provides ample control for exploring my backyard. Even though the 68hc811e2 chip that I used in my BB+ only has 2K bytes of EEPROM for program storage, this code weighs in at less than 1K, leaving me plenty of room for more features.

```
'==============================================
'
' tackle02.bas
'
' This code supports the motors and pan head. It also accepts
' one-key commands over the serial port (SCI).
'

include "regs11.lib"
include "servos.bas"

'
' Motor control constants, used by the RTI ISR code to support the
' motors. These constants assume the motors connect as follows:
'
' PB0   1 means right motor goes forward, 0 means no motion
' PB1   1 means right motor reverses, 0 means no motion
' PB2   1 means left motor goes forward, 0 means no motion
' PB3   1 means left motor reverses, 0 means no motion
'
' Note that having PB0 and PB1 both high, or PB2 and PB3 both high, is
' an illegal state, and might damage the drive electronics.
'

const RMTR_FWD = $01
const RMTR_REV = $02
const LMTR_FWD = $04
const LMTR_REV = $08
const RMTR_STOP = 0
const LMTR_STOP = 0

const SPEED_HALF = $eeee
const SPEED_FULL = $ffff

const PAN_TOC = TOC2
const PAN_CW = $fdc0
const PAN_CCW = $ef80
const PAN_CENTER = $f500
const PAN_INC = (PAN_CW - PAN_CCW) / 6

'
' Variables
'

declare rmtr
declare lmtr
declare rpwm
declare lpwm
declare t
declare k
declare wait
declare n
declare panloc
declare panchg
declare speed

'
' Real-time interrupt (RTI) interrupt service routine
'
' This ISR supports down-counting timers, such as WAIT. It also
' supports PWM of both motors, through the RPWM and LPWM pattern
' variables and the two motor control variables, RMTR and LMTR.
'
' This routine assumes port b controls the motors. See the constant
' declarations above for pin assignments.
'

interrupt $fff0                     ' RTI ISR
pokeb tflg2, $40                    ' rearm rti
if wait <> 0                                            ' need to decrement wait?
        wait = wait - 1                                 ' if so, do it
endif
t = 0                                                   ' assume no motor voltage
if rpwm and 1 = 1                                       ' if right motor is on...
        t = rmtr                                        ' show it
endif
if lpwm and 1 = 1                                       ' if left motor is on...
        t = t or lmtr                                   ' show it
endif
pokeb portb, ((peekb(portb) and $f0) or t)              ' set the motors
rpwm = rroll(rpwm)                                      ' roll masks for next time
lpwm = rroll(lpwm)
end

'
' SetMotor   change the direction of the current motion
'
' Invocation: gosub SetMotor, LeftDir, RightDir
'
' Note: This routine momentarily disables interrupts while it changes
' the low-level motor variables lmtr and rmtr.
'

SetMotor:
interrupts off                                          ' no interrupts
rmtr = pull()                                           ' save new direction values
lmtr = pull()
interrupts on                                           ' allow interrupts
return

'
' SetSpeed   change the speed of the current motion
'
' Invocation: gosub SetSpeed, LeftSpeed, RightSpeed
```

## That's a wrap

I've presented here the highlights of my latest additions to Tacklebot, a tethered robot suitable for outdoors exploration. You can build on these ideas for your own robot, and the program listing should help you in your firmware design. Be sure to visit my web site for SBasic, and to see some pictures of Tacklebot in its earlier incarnation.

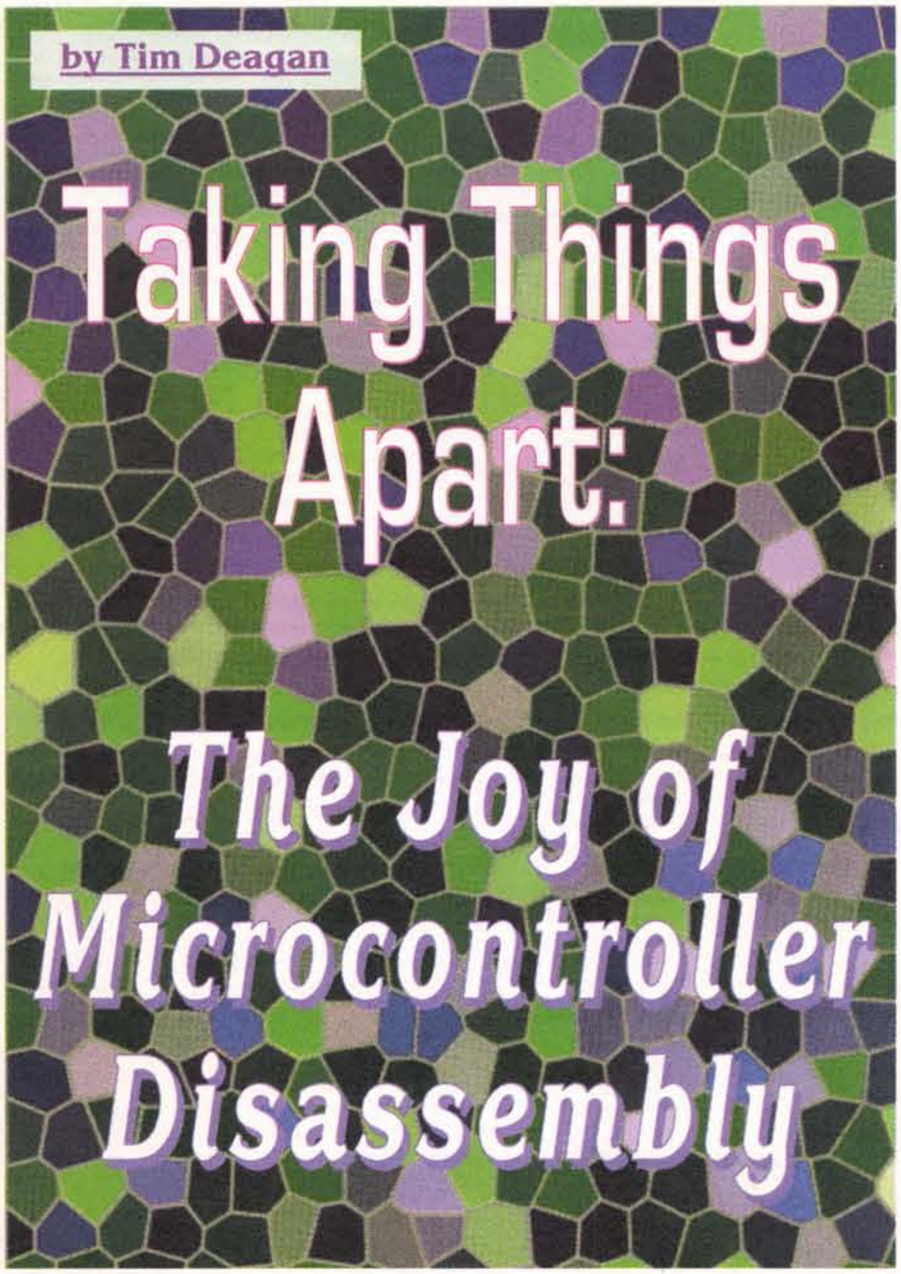
*And above all, have fun with this hobby!* **NV**

```
'
' Note: This routine momentarily disables interrupts while it changes
' the low-level motor variables lpwm and rpwm.
'
SetSpeed:
interrupts off                          ' no interrupts
rpwm = pull()                           ' save new PWM values
lpwm = pull()
interrupts on                           ' allow interrupts
return


'
' GetKey()  read a char from the serial port
'
' This routine returns 0 if no key is available or
' the key if one was available.
'
GetKey:
push inkey()                            ' check for key and save it
if pick(0) > 0                          ' if got a key...
        place 0, pick(0) and $ff        ' mask off bit 8
endif
return pull()                           ' return the key (or 0)



main:
pokeb baud, $30                         ' 9600 baud
pokeb sccr2, $0c                        ' turn on rcvr and xmtr
print
print "tackle02"
gosub SetSpeed, 0, 0                    ' start with motors stopped
gosub SetMotor, LMTR_STOP, RMTR_STOP
gosub InstallServo, PAN_TOC             ' connect to the servo motor
poke PAN_TOC, PAN_CENTER                ' move to center position

print
print "Press 'G' to begin...";          ' instruct the user

pokeb portb, 0                          ' all port b lines low
pokeb tflg2, %01000000                  ' set up RTI
pokeb tmsk2, %01000000                  ' arm RTI

wait = 0
interrupts on                           ' allow interrupts

do
        k = usr(GetKey)                 ' wait for user to enter a key
loop until k = 'G'                      ' must enter a G
print
print "Ready to rock!"

do                                      ' do forever...
        do
                k = usr(GetKey)         ' get a key
        loop until k <> 0               ' loop until something to do
        panchg = 0
        select k                        ' based on key...
                case '1'                ' 1-7 aligns the camera pan head
                case '2'
                case '3'
                case '4'
                case '5'
                case '6'
                case '7'
                panloc = PAN_CCW + (PAN_INC * (k - '1'))
                poke PAN_TOC, panloc
                endcase

                case ' '                ' space means stop motors
                gosub SetSpeed, 0, 0
                gosub SetMotor, LMTR_FWD, RMTR_FWD
                print "Stop ";
                endcase

                case 'f'                ' f means forward
                gosub SetSpeed, speed, speed
                gosub SetMotor, LMTR_FWD, RMTR_FWD
                print "Forward ";
                endcase

                case 'b'                ' b means backward
                gosub SetSpeed, speed, speed
                gosub SetMotor, LMTR_REV, RMTR_REV
                print "Backward ";
                endcase

                case 'r'                ' r means right turn
                gosub SetSpeed, speed, speed
                gosub SetMotor, LMTR_FWD, RMTR_REV
                print "Right ";
                endcase

                case 'l'                ' l means left turn
                gosub SetSpeed, speed, speed
                gosub SetMotor, LMTR_REV, RMTR_FWD
                print "Left ";
                endcase

                case 'q'                ' q sets full speed
                speed = SPEED_FULL
                gosub SetSpeed, 0, 0
                print "Full speed ";
                endcase

                case 'z'                ' z sets half speed
                speed = SPEED_HALF
                gosub  SetSpeed, 0, 0
                print "Half speed ";
                endcase

                case 'e'                ' e means lights on
                pokeb portb, peekb(portb) or $30
                print "Lights on ";
                endcase

                case 'c'                ' c means lights off
                pokeb portb, peekb(portb) and $cf
                print "Lights off ";
                endcase

                print "What? ";   ' no idea...
        endselect
loop
```

by Tim Deagan

# Taking Things Apart: The Joy of Microcontroller Disassembly

## Part 1



I like to take things apart. I love that special joy of discovering how something works from the inside out. For me, this is as true for software as it is for hardware. One of the things I like best about working with microcontrollers is the tight coupling between the assembly code and what happens on the pins. But there is a part of the experience that is opaque, the part between the assembly code and the execution, the Machine Code.

Too many times, I've found a bunch of poorly organized hex files on a disk, or pulled a hex file off an unlabeled chip with no idea what it does. All I have is a mess of hexadecimal numbers. Through careful disassembly, these can be turned back into human-readable programs. Call me a nerd, but I've found that teasing understanding out of the mystery of machine code is extremely satisfying, not to mention educational.

This article will describe the basic concepts you need to understand how a disassembler works. I will focus on the Microchip instruction set for the ever-popular PIC 16C84 and the Intel INHX8M hex file format, but the ideas hold true for any microcontroller. The conclusion of this article, appearing in next month's issue, will describe how to actually write a disassembler using the delightful Python programming language.

### Examining Assembly Language

The first thing to understand is the difference between assembly language and a high-level language like Basic or C. Assembly opcodes, or mnemonics, are very close to the commands the machine actually understands. They typically do very simple things (especially in a Reduced Instruction Set Computer or RISC chip such as the PIC) like 'ADD RegisterQ, 20' or 'JUMP endloop.'

Complicated actions are built up out of a bunch of these simple commands. A line in an assembly-language program is very consistent. It may have a label, an opcode, one or two arguments, and possibly a comment. High-level languages tend to have commands that are built out of many assembly commands like 'FOR a = 1 to 10' or 'SEROUT 1,12,300,14,' making it relatively easy to do complicated activities.

A compiler turns these commands into assembly language for the programmer. Many programmers prefer working in assembly language because they can control the efficiency and size of the program better than a compiler can.

Once the assembly language program is written, it is put through an assembler. An assembler is a program that turns the assembly- language source code into the set of bits that is machine code.

Assemblers are available from a number of sources with a variety of features, but the essential function of producing machine code is always the same. Assemblers will usually provide an option to generate either a collection of the bytes laid out as they will be on the chip, which is an object file or a file specially formatted for use with a programming device, which is often an Intel Hex File. Both file types represent machine code.

For the purpose of narrowing the discussion, I will use the Intel Hex File format in my description of disassembly, but the principles are the same for either type of file.

An assembly language program is readable by humans with a little training. (See Listing 1 for an example program.) Careful use of whitespace, variable names, and labels can make it much easier to understand. Many assemblers allow macros — or defined sequences of commands — to be used in code, as well. This simplifies programming and can simulate many of the features of a high-level language. I will stick to straight-assembly language as we look at examples to keep things simple.

When the assembler turns the assembly opcodes into hexadecimal sequences, it will optionally produce a listing file, as well (see Listing 2). This file shows the assembly language program side by side with the hex bytes it is turned into. It also shows the address of each command. This is

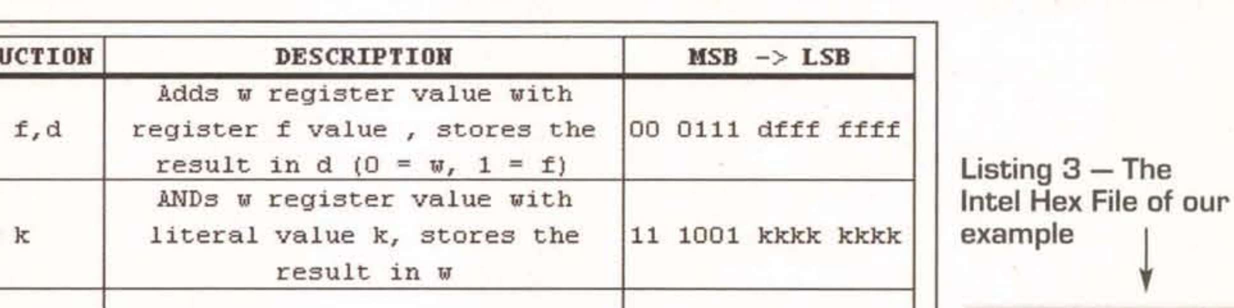



Figure 1 — The Intel Hex File (INHX8M) format

| INSTRUCTION | DESCRIPTION | MSB -> LSB |
|---|---|---|
| ADDWF f,d | Adds w register value with register f value , stores the result in d (0 = w, 1 = f) | 00 0111 dfff ffff |
| ADDLW k | ANDs w register value with literal value k, stores the result in w | 11 1001 kkkk kkkk |
| BSF f,b | Sets bit number b in register f | 01 01bb bfff ffff |

Table 1 — Example PIC instruction formats

Listing 3 — The Intel Hex File of our example

```
:100000008316003086000030850083120030AA007D
:10001000103OAB000230AC00AA0AAA1D1128AA01B8
:10002000AA0A2A082B0786001030AB07AB1F1A2834
:10003000AB01AB002B082A078600AC0AAC1D2228B6
:0C004000AC01AC0A2C0885000C28630001
:00000001FF
```

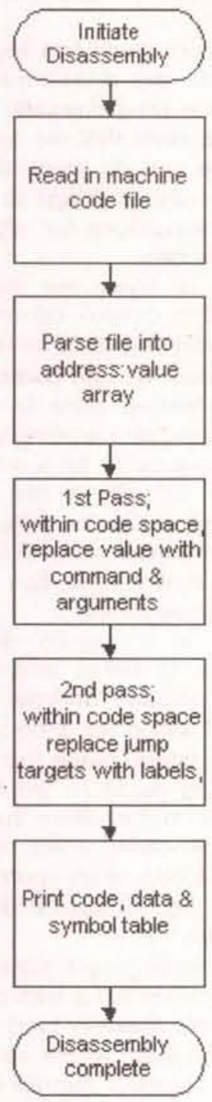



**Figure 2 — A basic disassembly flowchart**

an extremely useful tool for verifying what is really being put onto the chip.

An assembly language opcode and its arguments fit into a very specific set of bits. In the PIC 16C84 family, 14 bits are allotted to hold the command and arguments. The format of these bits is carefully defined (see Table 1.) These bits — or the bits collected together as bytes — constitute the machine code, usually viewed in hexadecimal notation.

Labels and comments are not stored in the machine code. A label represents which number, or address, in the program a command is at; this can be reconstructed from the sequence of commands by the machine. The comment is for humans and the machine doesn't care about it so it never makes it into the machine code.

### The Intel Hex File

Once the machine code is ready as a set of bits, it needs to be moved onto a chip to be useful. This can happen in a number of ways depending on the chip's technology, but it generally involves a special device used to program the chip such as an EPROM programmer or 'burner.' Most of these devices feed one byte or word (two bytes) at a time to the chip. Lots of manufacturers and hobbyists have produced programmers, but almost all of them use a standard format designed to make it easy to feed the bytes to the chip.

A number of formats are used; arguably the most common is the Intel Hex File format INHX8M. (I'll just refer to it as Intel Hex Format.) For brevity's sake, I will focus on only this format. Other formats serve a similar purpose and are easy to understand if you start with the Intel Hex Format first.

The basic format of the Intel Hex File is very simple (see Figure 1). A colon starts a line followed by a byte specifying the number of data bytes on the line. Next is the starting address for the data on the line. A byte follows that defines whether this is the end-of-file or not. The data bytes come next. A CRC checksum of the line is the last byte on the line. Lines can be variable in length.

### A Multipass Disassembler

Our first step in disassembly (see Figure 2) is to strip out the meaningful bytes from the hex file (see Listing 3) and assign them addresses. Using

| ADDR | WORD | LABEL | OPERAND | ARG1,ARG2 | |
|---|---|---|---|---|---|
| 0000 | 1683 | | BSF | STATUS,0x5 | ;Restart Vector |
| 0001 | 3000 | | MOVLW | 0x0 | |
| 0002 | 0086 | | MOVWF | PORTB/TRISB | |
| 0003 | 3000 | | MOVLW | 0x0 | |
| 0004 | 0085 | | MOVWF | PORTA/TRISA | ;Interrupt Vector |
| 0005 | 1283 | | BCF | STATUS,0x5 | |
| 0006 | 3000 | | MOVLW | 0x0 | |
| 0007 | 00AA | | MOVWF | 0x2a | |
| 0008 | 3010 | | MOVLW | 0x10 | |
| 0009 | 00AB | | MOVWF | 0x2b | |
| 000A | 3002 | | MOVLW | 0x2 | |
| 000B | 00AC | | MOVWF | 0x2c | |
| 000C | 0AAA | TARG_1: | INCF | 0x2a,F | |
| 000D | 1DAA | | BTFSS | 0x2a,0x3 | |
| 000E | 2811 | | GOTO | TARG_4 | |
| 000F | 01AA | | CLRF | 0x2a | |
| 0010 | 0AAA | | INCF | 0x2a,F | |
| 0011 | 082A | TARG_4: | MOVF | 0x2a,W | |
| 0012 | 072B | | ADDWF | 0x2b,W | |
| 0013 | 0086 | | MOVWF | PORTB/TRISB | |
| 0014 | 3010 | | MOVLW | 0x10 | |
| 0015 | 07AB | | ADDWF | 0x2b,F | |
| 0016 | 1FAB | | BTFSS | 0x2b,0x7 | |
| 0017 | 281A | | GOTO | TARG_3 | |
| 0018 | 01AB | | CLRF | 0x2b | |
| 0019 | 00AB | | MOVWF | 0x2b | |
| 001A | 082B | TARG_3: | MOVF | 0x2b,W | |
| 001B | 072A | | ADDWF | 0x2a,W | |
| 001C | 0086 | | MOVWF | PORTB/TRISB | |
| 001D | 0AAC | | INCF | 0x2c,F | |
| 001E | 1DAC | | BTFSS | 0x2c,0x3 | |
| 001F | 2822 | | GOTO | TARG_2 | |
| 0020 | 01AC | | CLRF | 0x2c | |
| 0021 | 0AAC | | INCF | 0x2c,F | |
| 0022 | 082C | TARG_2: | MOVF | 0x2c,W | |
| 0023 | 0085 | | MOVWF | PORTA/TRISA | |
| 0024 | 280C | | GOTO | TARG_1 | |
| 0025 | 0063 | | SLEEP | | |

**SYMBOL TABLE**

| ADDR | SYMBOL |
|---|---|
| 000C | TARG_1 |
| 0011 | TARG_4 |
| 001A | TARG_3 |
| 0022 | TARG_2 |
| 0000 | INDO |
| 0001 | TMR0/RTCC/OPTION |
| 0002 | PCL |
| 0003 | STATUS |
| 0004 | FSR |
| 0005 | PORTA/TRISA |
| 0006 | PORTB/TRISB |
| 0008 | EEDATA/EECON1 |
| 0009 | EEADR/EECON2 |
| 000A | PCLATH |
| 000B | INTCON |

**Listing 4 — Disassembler output**

**Listing 1 — A simple assembly-language program**

```
STATUS      equ     03
PORTA       equu    05
PORTB       equ     06
TRISA       equ     05
TRISB       equ     06
RP0         equ     05

LED1REG     equ     02a
LED2REG     equ     02b
LED3REG     equ     02c

        wdtoff

        bsf     STATUS,RP0          ;init ports
        movlw   00
        movwf   TRISB
        movlw   00
        movwf   TRISA
        bcf     STATUS,RP0

        movlw   00                  ;init led*reg
        movwf   LED1REG
        movlw   010
        movwf   LED2REG
        movlw   002
        movwf   LED3REG

loop    incf    LED1REG             ;inc led1reg
        btfss   LED1REG,3           ;skip next if >= 8
        goto    led1                ;jump
        clrf    LED1REG             ;clear led1reg
        incf    LED1REG             ;ledreg1 = 1

led1    movf    LED1REG,w           ;move led1reg to w
        addwf   LED2REG,w           ;combine with led2reg
                                    ;in w

        movwf   PORTB               ;output on portb

        movlw   010                 ;setup w with increment
        addwf   LED2REG,f           ;inc led2reg (high nibble)
        btfss   LED2REG,7           ;skip next if >= 8
        goto    led2                ;jump
        clrf    LED2REG             ;clear led2reg
        movwf   LED2REG             ;ledreg1 = 0x10
led2    movf    LED2REG,w           ;move led2reg to w
        addwf   LED1REG,w           ;combine with led1reg
                                    ;in w

        movwf   PORTB               ;output on portb

        incf    LED3REG             ;inc led3reg
        btfss   LED3REG,3           ;skip next if >= 8
        goto    led3                ;jump
        clrf    LED3REG             ;clear led3reg
        incf    LED3REG             ;led3reg = 1
led3    movf    LED3REG,w           ;moveled3reg t

        movwf   PORTA               ;output on porta

        goto    loop                ;do it all over again

        sleep

        END
```

the format of the hex file as a guide, this is quite simple. Each line from the hex file is taken in turn.

We parse the line by taking the starting address from the line and using it as the address of the first byte. In the case of the PIC 14 bit instruction set, we have to use two bytes to represent an opcode. The additional two bits of the high byte are ignored.

We then use the byte count from the line to determine how many additional bytes to work through, incrementing the address count for each byte. Since we are disassembling PIC 14 bit instructions, we won't assign a new address to each byte, but for each word.

We now have a list of machine codes with addresses. Either as a second step, or concurrently with our first step, we can turn the machine code into recognizable opcode mnemonics. This process involves using a sieve to sort through the bits of the machine code to make a match with an opcode. The opcodes are typically grouped into sets of opcodes that share bit patterns. This makes it easy to rapidly determine, by checking a couple of bits which group, then by checking additional bits to narrow further and so on. When we finally reach the target opcode, we can parse the arguments out of the bits, as well.

When this process is complete, we have an addressed list of recognizable opcode mnemonics with arguments. The simplest version of a first pass disassembly is complete and the result is already useable!

At this point, we can begin to add value to the disassembly by adding some programmatic complexity. The code that we execute in our sieve can do many things. One of the easiest things to do is swap out hex values for registers wherever we can.

We know from our opcode structure that certain commands always expect registers as one of the arguments. We can construct a subroutine lookup table to determine which register is being targeted and swap a name for a number.

This is actually a tad more complicated with the PIC and many other microcontrollers. The problem is that the PIC has different banks of registers.

A flag in a register defines which bank is being addressed. The same register address argument could stand for a couple of different registers. Since the register bank flag could be set by an interrupt or some other hard-to-track code, knowing which bank is being addressed takes more of a microcontroller simulator than a disassembler.

This is easy to get around by replacing the hex value with the list of all possible (usually two) registers. This is a place where we strike a balance between human intelligence and program intelligence, rather than over-program a solution.

A second pass of disassembly allows even more interesting things to be done, the best of which is adding labels to our code and then replacing the hex values after jumps with the names of the labels we created. This makes the disassembled code much more readable.

We do this by running through the results of our first pass and collecting all the targets of jump commands. We then use this list to create unique labels at each of the addresses in our list of targets. We can then replace all of the jump targets with the unique label names we created.

We can also produce one of the other useful items that an assembler produces: a symbol table. This is a simple table of associations between names and numbers.

The names may be labels and the numbers addresses, or the names may be registers and the numbers the register number.

When writing assembly language, it's also possible to assign names to addresses or values for the sake of readability. Disassemblers can easily provide the label and register associations.

The variable names are not provided since the computer has no way of knowing what arbitrary numbers a human might like to see as a name.

Many microcontrollers also have special registers that are set via the hex file. An example on the PIC 16C84 would be the register that defines — among other things, what kind of oscillator is being used — the config word (address 0x2007). This register is at a consistent location outside of the range of addresses defined as holding code, so we can spot it in the hex file and decode it into the flags that are set or cleared.

The disassembly listing can describe the status of these flags, or even reproduce the commands an assembler would want to see if you were trying to work with the register in code.

Now we have an assembly language program (see Listing 4) that is quite readable. It has clearly labeled opcode mnemonics, registers, and jump labels. This code could be used by an In-Circuit Emulator (see the Jan. 99' *Nuts & Volts*, "Your Hottest Tool May be ICE!") to single step through code, understand how a complicated interrupt scheme is set up, or any number of other educational purposes.

In the conclusion of this article next month, I'll show how a disassembler can be written. I'll use Python, the open-source language that is considerably easier to read than many other languages.

I'll describe the operations needed to do multipass disassembly and even demonstrate how to have the program create a symbol table and comment some lines. A working disassembler will be provided with source so that experimenters can adapt it to their own needs. **NV**

## Disassembly Resources

**The Simtel.Net MS-DOS Collection Disassemblers**
http://www.eunet.bg/simtel.net/msdos/disasm-bydate.html

**XDASM - Universal Cross Disassembler**
http://www.datasynceng.com/xdasmdoc.htm

**Programmers Heaven Assembler Zone**
Assemblers/Disassemblers Filelist
http://www.programmersheaven.com/zone5/cat25/index.htm

**Open Directory — Computers: Programming: Disassemblers**
http://dmoz.org/Computers/Programming/Disassemblers/

## PIC Resources

**Microchip**
http://www.microchip.com/

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http://come.to/thepicarchive

**Microchip Net resources**
http://www.geocities.com/SiliconValley/Way/5807/

### Listing 2 — The List file output from an assembler

```
LOC OBJECT  LINE   SOURCE   TEXT
  CODE
 VALUE

00000003    00001  STATUS   equ  03
00000005    00002  PORTA    equ  05
00000006    00003  PORTB    equ  06
00000005    00004  TRISA    equ  05
00000006    00005  TRISB    equ  06
00000005    00006  RP0      equ  05
            00007
0000002A    00008  LED1REG  equ   02a
0000002B    00009  LED2REG  equ  02b
0000002C    00010  LED3REG  equ  02c
            00011
            00012
Warning[207]: Found label after column 1. (wdtoff)
0000        00013                wdtoff
            00014
0000 1683   00015                BSF STATUS,RP0
0001 3000   00016                MOVLW 00
0002 0086   00017                MOVWF TRISB
0003 3000   00018                MOVLW 00
0004 0085   00019                MOVWF TRISA
0005 1283   00020                BCF STATUS,RP0
            00021
            00022
0006 3000   00023                movlw  00  ;init led*reg
0007 00AA   00024                movwf  LED1REG
0008 3010   00025                movlw  010
0009 00AB   00026                movwf  LED2REG
000A 3002   00027                movlw  002
000B 00AC   00028                movwf  LED3REG
            00029
Message[305]: Using default destination of 1 (file).
000C 0AAA   00030 loop      incf  LED1REG          ;inc led1reg
000D 1DAA   00031                btfss  LED1REG,3  ;skip next if >= 8
000E 2811   00032                goto  led1ok            ;jump
000F 01AA   00033                clrf  LED1REG     ;clear led1reg
Message[305]: Using default destination of 1 (file).
0010 0AAA   00034                incf  LED1REG     ;ledreg1 = 1
0011 082A   00035 led1ok    movf  LED1REG,w    ;move led1reg to w
0012 072B   00036                addwf  LED2REG,w  ;combine with
                                                   ;led2reg in w
            00037
0013 0086   00038                movwf  PORTB      ;output on portb
            00039
0014 3010   00040                movlw  010        ;setup w with
                                                   ;increment
0015 07AB   00041                addwf  LED2REG,f  ;inc led2reg (high
                                                   nibble)
0016 1FAB   00042                btfss  LED2REG,7  ;skip next if >= 8
0017 281A   00043                goto  led2ok            ;jump
0018 01AB   00044                clrf  LED2REG     ;clear led2reg
0019 00AB   00045                movwf  LED2REG    ;ledreg1 = 0x10
001A 082B   00046 led2ok    movf  LED2REG,w    ;move led2reg to w
001B 072A   00047                addwf  LED1REG,w  ;combine with
                                                   ;led1reg in w
            00048
001C 0086   00049                movwf  PORTB      ;output on portb
            00050
```

```
Message[305]: Using default destination of 1 (file).
001D 0AAC   00051                incf  LED3REG     ;inc led3reg
001E 1DAC   00052                btfss  LED3REG,3  ;skip next if >= 8
001F 2822   00053                goto  led3ok            ;jump
0020 01AC   00054                clrf  LED3REG     ;clear led3reg
Message[305]: Using default destination of 1 (file).
0021 0AAC   00055                incf  LED3REG     ;led3reg = 1
0022 082C   00056 led3ok    movf  LED3REG,w    ;moveled3reg t
  00057
0023 0085   00058                movwf  PORTA      ;output on porta
  00059
0024 280C   00060                goto  loop        ;do it all over again
  00061
0025 0063   00062                sleep
            00063
            00064                END

SYMBOL TABLE
LABEL          VALUE

LED1REG        0000002A
LED2REG        0000002B
LED3REG        0000002C
PORTA          00000005
PORTB          00000006
RP0            00000005
STATUS         00000003
TRISA          00000005
TRISB          00000006
__16C84        00000001
led1ok         00000011
led2ok         0000001A
led3ok         00000022
loop           0000000C
wdtoff         00000000

MEMORY USAGE MAP ('X' = Used, '-' = Unused)

0000 : XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXX XXXXXX---------- ----------------

All other memory blocks unused.

Program Memory Words Used:    38
Program Memory Words Free:    986

Errors   :    0
Warnings :    1 reported,     0 suppressed
Messages :    4 reported,     0 suppressed
```

Continued from page 42

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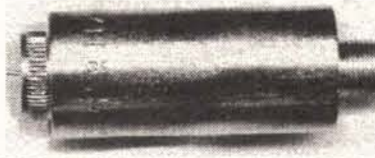

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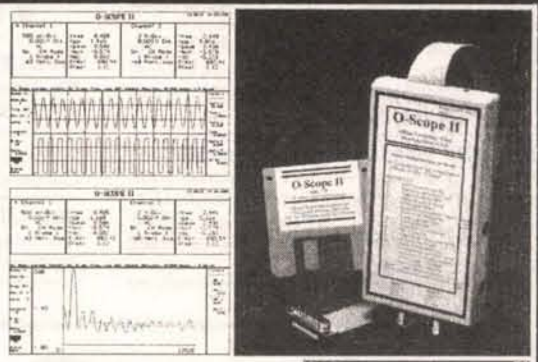

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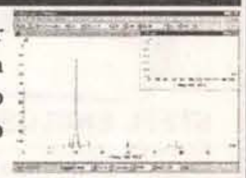

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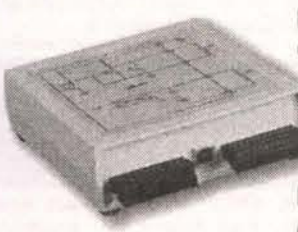

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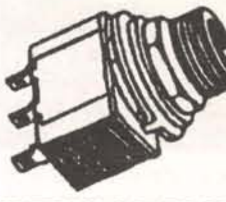

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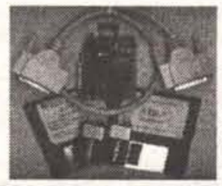

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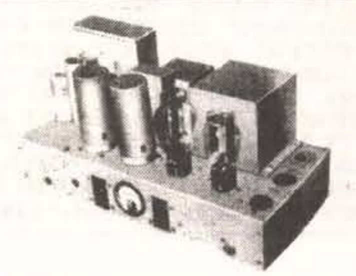

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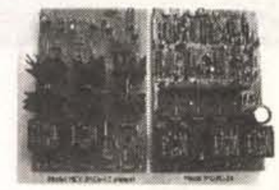

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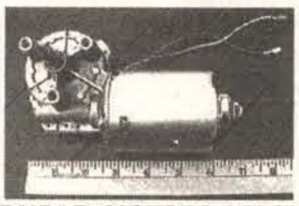

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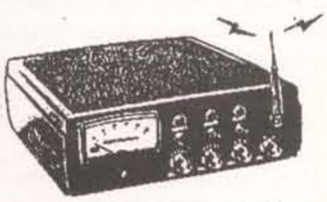

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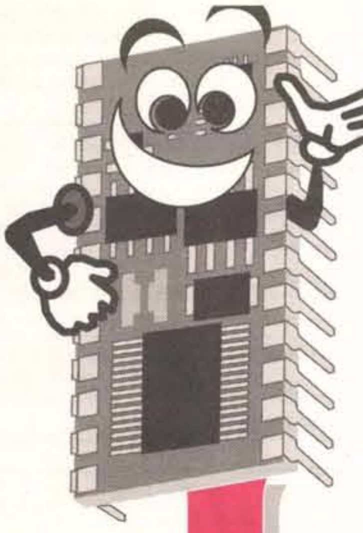


by Jon Williams

# Stamp Applications

## STAMPS IN THE LAB — PART 2



Last month, we had some fun by keeping our PC connected to the Stamp and displaying information with a neat little program from SelmaWare called Stamp Plot Lite. Later, we went on to create a Visual Basic program that was compatible with Stamp Plot Lite output statements.

In both cases, the Stamp acted as an "information provider" and just pumped out data. There will be times though, when we want to ask the Stamp for a specific piece of information. We may also want to set some information in the Stamp that affects its behavior. That's what we're going to do this month.

> Last month, our Stamp program did its processing and served up information without asking. This month, we've gone to the other extreme: the Stamp sits and waits for a command before doing anything. Can we find a happy middle ground?

### Building a Two-Way Street

Since we can't learn to swim without getting wet, let's jump right in. Take a look at the Stamp program in Listing 1 (if you don't have a Parallax BASIC Stamp Activity Board, you can build an equivalent circuit using the schematics provided last month).

After the obligatory setup and initialization, the program waits on some serial input from the PC — in this case, coming in on the programming port (defined as Pin 16). The input, specifically, is going to start with a question mark and be followed by a hexadecimal number. This (hex) number is our query; it tells the Stamp what we want.

Why do it this way? Well, there are a couple of reasons. By using the HEX modifier in the SERIN function, we're able to receive data in the form of ASCII text. This data could come from a Visual Basic program, but we haven't written that yet. Since we want to be sure the Stamp code is working as expected before we tackle the PC side of things, it would be nice if we could use some other tool to do our testing. With this technique, we can. Since the Stamp is expecting a string input, we can use a general-purpose terminal program to see if things are working. We can even use a DEBUG terminal in the Windows version of the Stamp editor.

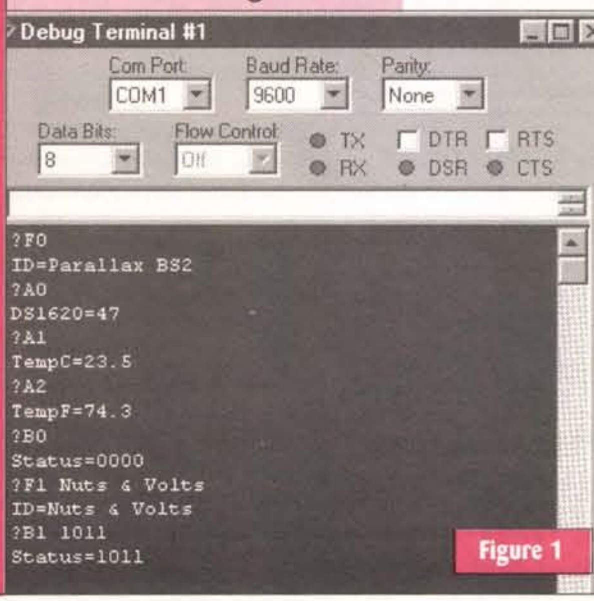


Figure 1

Let's go back to our SERIN function and discuss the details. First, SERIN waits for the "?" character to arrive, ignoring everything else until that happens. The question mark, then, is what signifies the start of a query. Once a question mark arrives, the HEX modifier causes the Stamp to look for valid hex characters (0-9, A-F). The arrival of any non-hex character (usually a carriage return [Enter] when using a terminal) tells the Stamp to stop accepting input (to the variable called param in our case) and continue on.

What has actually happened is that the Stamp has used the SERIN function to do a text-to-numeric conversion. Pretty cool, huh? Now that we have a command, we can use standard IF-THEN logic statements to see if it is valid for our particular program. (Since there are so many possible commands and they are not numerically contiguous, using BRANCH to jump to the requested routine becomes a bit awkward.) If the command isn't valid, a message and the offending input is displayed.

Could we have used "?ID" instead of "?F0" to get the Stamp's identification string? Yes, technically we could have, but it becomes very tedious in PBASIC programming. The reason is that the Stamp can't do direct string comparisons. What we would have to do is compare the input, character-by-character, to see if it's valid. And to be user-friendly, we'd have to allow uppercase and lowercase entries — doubling the number of comparisons. Since the HEX modifier of SERIN is not case-sensitive, our program will work if we enter "?F0" or "?f0" or any upper/lower combination.

For an example of character-by-character string comparisons in the Stamp, take a look at Jon Richards' networking demo at www.jdrichards.com.

The Stamp responds to a request by sending a text string by using DEBUG. Remember that DEBUG in the BS2 is the same as SEROUT on pin 16 at 9600 baud. Each of the response strings consists of a label, the equal sign, the value of that particular parameter, and finally, a carriage return. When using a terminal program, the output is easily readable. Something like this:

```
ID=Parallax BS2
```

The carriage return at the end of the output gives us a new line when using a terminal program and serves as an "end of input" when we process the input with our own program (like Stamp Plot Lite does). The equal sign will be used as a delimiter when we do our own processing. We'll use it to distinguish the label from its value.

Most of our queries are requests for information. Two of them, however, can modify information that is stored in the Stamp. Let's look at those.

The first one is "?F1" which will allow us to write a string value to the Stamp's EEPROM (in a location called ID). When F1 is received as a command value, the program jumps to the subroutine called SetID. On entry to SetID, the EE pointer called addr is initialized, then the Stamp waits for a character to arrive. Notice that no modifier is used here. Since terminal programs and the Stamp represent characters using ASCII codes, we don't have to do anything special. When a character does arrive, it is written to the EE and the address pointer is incremented. If the last character was a carriage return (13), the program outputs the new string (using the code at ShowID), otherwise it loops back and waits for another character.

The second modifying query is "?B1" which allows us to set the status of four LEDs. Take a look at the subroutine called SetLEDs. This time, we're going to use the BIN modifier of SERIN. What this means is that our valid inputs are going to be "1" (LED is on) and "0" (LED is off). Since the hardware uses active low outputs, we're forced to invert the data. That's easily handled with the complement operator (~).

Figure 1 shows an actual online session with this Stamp program using the DEBUG terminal. If you're not using the Windows Stamp

```
' Nuts & Volts - Stamp Applications
' August 2000 (Listing 1)

' =========================================================================
' Program... POLLSTMP.BS2
' Author.... Jon Williams
' Started... 25 MAY 2000
' Updated... 29 JUN 2000
' =========================================================================

' -----[ Program Description ]---------------------------------------------
'
' This program waits for a text command from the PC and responds with a
' string that contains the name of the data and its current value.
'
' If the ATN line is opened, this program will work with any general-
' purpose terinal program (i.e., HyperTerm).  To read the temperature you
' would type the characters '?', 'A', '1', followed by a carriage return.


' -----[ Revision History ]------------------------------------------------
'


' -----[ I/O Definitions ]-------------------------------------------------
'
SIOpin   CON     16                      ' serial I/O on programming port

Rst      CON     13                      ' DS1620.3
Clk      CON     14                      ' DS1620.2
DQ       CON     15                      ' DS1620.1

' -----[ Constants ]-------------------------------------------------------
'
Baud96   CON     84                      ' 9600-8-N-1 (matches DEBUG)

CmdID    CON     $F0                     ' get string ID
CmdSet   CON     $F1                     ' set string ID
CmdTmp   CON     $A0                     ' get DS1620 - display raw count
CmdTmpC  CON     $A1                     ' get DS1620 - display in C
CmdTmpF  CON     $A2                     ' get DS1620 - display in F
CmdStat  CON     $B0                     ' get digital output status
CmdLEDs  CON     $B1                     ' set LED outputs

' DS1620 commands
'
RTmp     CON     $AA                     ' read temperature
WTHi     CON     $01                     ' write TH (high temp register)
WTLo     CON     $02                     ' write TL (low temp register)
RTHi     CON     $A1                     ' read TH
RTLo     CON     $A2                     ' read TL
StartC   CON     $EE                     ' start conversion
StopC    CON     $22                     ' stop conversion
WCfg     CON     $0C                     ' write configuration register
RCfg     CON     $AC                     ' read configuration register

' -----[ Variables ]-------------------------------------------------------
'
cmd      VAR     Byte                    ' command from PC/terminal
addr     VAR     Byte                    ' EE address pointer
eeDat    VAR     Byte                    ' EE data
param    VAR     Word                    ' parameter from PC
char     VAR     param.LOWBYTE
tmpIn    VAR     Word                    ' raw data from DS1620
halfBit  VAR     tmpIn.Bit0              ' 0.5 degree C indicator
sign     VAR     tmpIn.Bit8              ' 1 = negative temperature
tempC    VAR     Word                    ' degrees C in tenths
tempF    VAR     Word                    ' degrees F in tenths
potVal   VAR     Word                    ' reading from BSAC pot
buttons  VAR     Nib                     ' BSAC input buttons


' -----[ EEPROM Data ]-----------------------------------------------------
'
ID       DATA "Parallax BS2", CR         ' CR-terminated string


' -----[ Initialization ]--------------------------------------------------
'
         OUTC = %1111                    ' turn off LEDs (active low)
         DIRC = %1111                    ' make port C all outputs

         HIGH Rst                        ' alert the DS1620
         ' use with CPU; free run mode
         SHIFTOUT DQ,Clk,LSBFIRST,[WCfg, %10]
         LOW Rst
         PAUSE 10                        ' pause for DS1620 EE write cycle
         HIGH Rst
         ' start temp conversion
         SHIFTOUT DQ,Clk,LSBFIRST,[StartC]
         LOW Rst

' -----[ Main ]------------------------------------------------------------
'
Main:    ' wait for a command
         cmd = 0
         SERIN SIOpin,Baud96,[WAIT ("?"),HEX cmd]

         ' check for valid command

         IF cmd = CmdID THEN ShowID
         IF cmd = CmdSet THEN SetID
         IF cmd = CmdTmp THEN ShowTemp
         IF cmd = CmdTmpC THEN ShowTempC
         IF cmd = CmdTmpF THEN ShowTempF
         IF cmd = CmdStat THEN ShowStat
         IF cmd = CmdLEDs THEN SetLEDs

BadCommand:
         DEBUG "Invalid Command: ",HEX2 cmd,CR
         GOTO Main


' -----[ Subroutines ]-----------------------------------------------------
'
ShowID:  DEBUG "ID="                             ' label output
         addr = ID                               ' point to first character of ID
GetEE:   READ addr, eeDat                        ' read a character from EEPROM
         DEBUG eeDat                             ' print the character
         addr = addr + 1                         ' point to next character
         IF eeDat <> CR THEN GetEE               ' if not CR, read another
         GOTO Main


SetID:   addr = ID                               ' point to ID location
GetC:    SERIN SIOpin,Baud96,[char]              ' get character from PC
         WRITE addr, char                        ' write character to EEPROM
         addr = addr + 1                         ' point to next location
         IF char <> CR THEN GetC                 ' if not CR, wait for another
         GOTO ShowID                             ' confirm new ID


ShowTemp:
         GOSUB GetTemp
         DEBUG "DS1620=",DEC tmpIn,CR            ' send raw temp to PC
         GOTO Main


ShowTempC:
         ' will only return temps above freezing (0 C)
         GOSUB GetTemp
         IF sign = 0 THEN NoNegC
         tmpIn = 0
NoNegC:  ' convert raw count to 10ths C
         tempC = tmpIn * 5
         DEBUG "TempC=",DEC (tempC/10),".",DEC (tempC//10),CR
         GOTO Main


ShowTempF:
         ' will only return temps above freezing (32 F)
         GOSUB GetTemp
         IF sign = 0 THEN NoNegF
         tmpIn = 0
NoNegF:  ' convert raw count to 10ths F
         tempF = (tmpIn * 9) + 320
         DEBUG "TempF=",DEC (tempF/10),".",DEC (tempF//10),CR
         GOTO Main


ShowStat:
         ' show LED status
         DEBUG "Status=", BIN4 ~OUTC, CR
         GOTO Main


SetLEDs:
         ' wait for output bits
         ' - as binary string
         '
         SERIN SIOpin,Baud96,[BIN param]
         OUTC = ~param.LOWNIB                    ' set the outputs
         GOTO ShowStat                           ' confirm new outputs


GetTemp:
         HIGH Rst                                ' alert the DS1620
         SHIFTOUT DQ,Clk,LSBFIRST,[RTmp]         ' read temperature
         SHIFTIN DQ,Clk,LSBPRE,[tmpIn\9]         ' get the temperature
         LOW Rst
         RETURN
```

editor, you can use any generic terminal program instead (make sure that Local Echo is disabled). Each command is terminated with a carriage return (Enter on the PC keyboard). For "?F1" and "?B1", a space was used as the separator between the command and the data. And don't forget the SERIN DEC modifier. If you develop a program (like this one) where you can enter data from a terminal, using the DEC modifier will make it easy.

### More BASIC to BASIC

Now that we have a Stamp project that will respond to requests, we can use Visual Basic to create a program that handles or even automates them for us. This is a pretty simple process; in fact, we only have to make a very small addition to the code that we created last month.

Essentially, we just have to build a command string for each of our functions and send it to the Stamp. What we have to keep in mind though is that the MSComm control in VB does not have the pacing parameter that the Stamp's SEROUT function has and we're going to be forced to code around this. We need some pacing between characters because we're using SERIN modifiers and, in the case of the ID string, we're writing the characters to the Stamp's EEPROM as they come in. These processes take time.

Listing 2 is the VB code for a small demo program (see Figure 2) that takes advantage of a couple of the features of our Stamp project. This program will allow us to get and set the identification string and set the BSAC LEDs.

Remember that Visual Basic is event-driven, that is, nothing happens until something happens. In our case, things get started when we connect to the Stamp (Connect on the Port menu) and then click on one of the buttons. Let's go through one.

When we click on the button labeled "Read," a subroutine called

```
' Nuts & Volts - Stamp Applications August 2000 (Listing 2)

' ======================================================================
' Program... PolledStamp.VBP
' Author.... Jon Williams
' Started... 25 MAY 2000
' Updated...  2 JUL 2000
' ======================================================================

Option Explicit

Dim rxBuffer As String          ' response from Stamp
Dim roundRobin As Byte          ' polling control
Dim okayToClose As Boolean      ' okay to quit program?

Private Declare Function timeGetTime Lib "winmm.dll" () As Long


Private Sub cmdIDRead_Click()

  SendStr ("?F0")

End Sub


Private Sub cmdIDWrite_Click()

  SendStr ("?F1 " & Trim(txtIDstring.Text))

End Sub


Private Sub cmdSetLEDs_Click()

  Dim x As Integer
  Dim ledStr As String

  ledStr = ""                         ' clear status string
  For x = 0 To 3                      ' build binary string of status
    If chkLED(x).Value = 1 Then
      ledStr = ledStr & "1"
    Else
      ledStr = ledStr & "0"
    End If
  Next

  SendStr ("?B1 " & ledStr)           ' send command and status

End Sub


Private Sub Form_Load()

  Dim x As Integer

  ' setup form
  Me.Left = (Screen.Width - Me.Width) / 2
  Me.Top = (Screen.Height - Me.Height) / 2
  Me.Caption = App.Title

  ' clear ID text
  txtIDstring.Text = ""
  cmdIDRead.Enabled = False
  cmdIDWrite.Enabled = False

  ' uncheck LEDs
  For x = 0 To 3
    chkLED(x).Value = 0
  Next
  cmdSetLEDs.Enabled = False

  ' setup comm object
  With MSComm1
    .CommPort = 1
    .Settings = "9600,N,8,1"          ' setup for DEBUG
    .DTREnable = mnuPortResetStamp.Checked
    .RThreshold = 1                   ' process one char at a time
    .InputLen = 1                     ' grab one char at a time
    .InputMode = comInputModeText       ' input will be strings
    .SThreshold = 0                     ' don't wait to send
  End With

  okayToClose = True

End Sub


Private Sub Form_QueryUnload(Cancel As Integer, UnloadMode As Integer)

  Cancel = Not (okayToClose)

End Sub


Private Sub Form_Unload(Cancel As Integer)

  If MSComm1.PortOpen Then MSComm1.PortOpen = False

End Sub


Private Sub mnuFileExt_Click()

  Unload Me

End Sub


Private Sub mnuPortComX_Click(Index As Integer)

  ' deselect last port
  mnuPortComX(MSComm1.CommPort).Checked = False
  ' select new
  MSComm1.CommPort = Index
  mnuPortComX(Index).Checked = True

End Sub


Private Sub mnuPortConnect_Click()

  Dim x As Byte

  If okayToClose And (Not (MSComm1.PortOpen)) Then
    ' open the port
    On Error GoTo PortError
    MSComm1.PortOpen = True
    ' update the title bar
    Me.Caption = App.Title & " [Connected]"
    ' update port menu
    For x = 1 To 4
      mnuPortComX(x).Enabled = False
    Next
    mnuPortConnect.Caption = "&Disconnect"
    ' enable form controls
    cmdIDRead.Enabled = True
    cmdIDWrite.Enabled = True
    cmdSetLEDs.Enabled = True
  Else
    ' close the port
    MSComm1.PortOpen = False
    ' update the title bar
    Me.Caption = App.Title
    ' update port menu
    For x = 1 To 4
      mnuPortComX(x).Enabled = True
    Next
    mnuPortConnect.Caption = "&Connect"
    ' disable form controls
    cmdIDRead.Enabled = False
    cmdIDWrite.Enabled = False
    cmdSetLEDs.Enabled = False
  End If
  Exit Sub

PortError:
```

# STAMPS IN THE LAB — PART 2

cmdIDRead_Click is executed. This subroutine calls SendStr with the data "?F0" (read the ID). If we jump down to SendStr, we see that it sends each character of the passed string with a five-millisecond delay in between them. Once all of the characters have been sent, it completes the transmission with a carriage return (13).

One of the details that we have to deal with when using the Stamp's programming port for general serial communications is that it echoes back everything that it receives. What this means is that every character we send to the Stamp through the programming port comes back in on the receive line. When a character arrives, the MSComm1_OnComm subroutine gets called.

MSComm1_OnComm collects all incoming characters in a string called rxBuffer until it sees a carriage return. When that happens, it passes the buffer to the subroutine (cleverly called) ProcessBuffer for handling.

ProcessBuffer looks at the first character of the incoming string. If it's a "?" we know that the string is the command we just sent and it can be discarded. If the first character is something else, we'll check it for "=" and parse the label and its parameter. A Select-Case structure lets us iterate through available labels and deal with the parameter. In the case of "ID", we send the parameter to the Identification text box. Prove to yourself that this works by clearing the text box and then clicking on "Read."

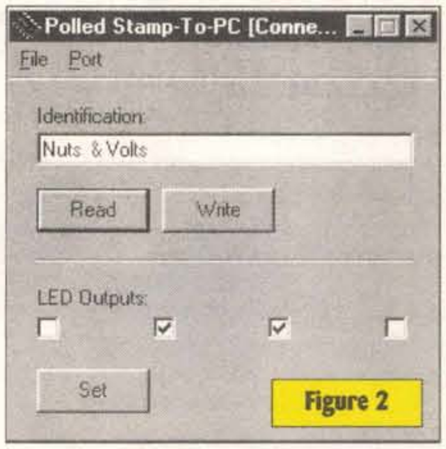



**Figure 2**

This is a simple demo and doesn't do a lot — but is a very good shell for any application of this sort that you might want to develop. And you can always

```
  MsgBox "Could not open Com" & Trim(Str(MSComm1.CommPort)) & ". " & _
         vbCr & "Please select another port.", _
         vbExclamation + vbOKOnly, App.Title

  On Error GoTo 0

End Sub


Private Sub mnuPortResetStamp_Click()

  mnuPortResetStamp.Checked = Not (mnuPortResetStamp.Checked)
  MSComm1.DTREnable = mnuPortResetStamp.Checked

End Sub


Private Sub MSComm1_OnComm()

  Dim newChar As String

  Select Case MSComm1.CommEvent
    Case comEvReceive
      newChar = MSComm1.Input
      If newChar = Chr(13) Then
        ProcessBuffer (rxBuffer)
        rxBuffer = ""
      Else
        rxBuffer = rxBuffer & newChar
      End If

    ' process other events here

  End Select

End Sub


Private Sub ProcessBuffer(ByVal buffer As String)

  Dim leadChar As String
  Dim delimPos As Integer
  Dim label As String
  Dim param As String

  ' get leading character
  leadChar = Mid(buffer, 1, 1)

  If leadChar = "?" Then
    ' echoed query - ignore
  Else
    ' process the response
    delimPos = InStr(1, buffer, "=")
    If delimPos > 0 Then
      ' extract label and parameter
      label = UCase(Trim(Mid(buffer, 1, delimPos - 1)))
      param = Trim(Mid(buffer, delimPos + 1))
      ' process known responses
      Select Case label
        Case "ID"
          txtIDstring.Text = param

        Case "DS1620"
          ' process raw temperature

        Case "TEMPC"
          ' display celcius temp

        Case "TEMPF"
          ' display fahrenheit temp

        Case "STATUS"
          ' confirm LED status

        Case Else
          ' unknown label

      End Select
    Else
      ' buffer has no delimiter
      ' (error message)
    End If
  End If

End Sub

Public Sub Delay(milliseconds As Single)
  Dim timeOut As Single

  timeOut = milliseconds + timeGetTime()
  Do Until timeGetTime() >= timeOut
    DoEvents
  Loop
End Sub


Private Sub SendStr(ByVal txBuf As String)

  Dim x As Integer

  ' can't quit while transmitting
  okayToClose = False

  For x = 1 To Len(txBuf)
    MSComm1.Output = Mid(txBuf, x, 1)
    ' give Stamp time to receive and process the character
    Delay (5)
  Next
  ' add CR to end of command
  MSComm1.Output = Chr(13)

  okayToClose = True

End Sub


Private Function Dec2Bin(ByVal decValue As Long) As String

  Dim tmpBin As String
  Dim testBit As Long

  tmpBin = ""
  testBit = 1

  Do
    If (testBit And decValue) > 0 Then
      tmpBin = "1" & tmpBin
      decValue = decValue - testBit
    Else
      tmpBin = "0" & tmpBin
    End If
    testBit = testBit * 2
  Loop While (decValue > 0)

  Dec2Bin = tmpBin

End Function

Private Function Bin2Dec(ByVal binValue As String) As Long

  Dim temp As Long
  Dim binLen As Integer
  Dim x As Integer

  temp = 0
  binLen = Len(binValue)
  For x = 1 To binLen
    ' add bit value if "1"
    If Mid(binValue, x, 1) = "1" Then
      temp = temp + 2 ^ (binLen - x)
    End If
  Next

  Bin2Dec = temp

End Function
```

# STAMPS IN THE LAB — PART 2

automate the polling by adding a timer to the project and using it to send a command. You can also use the PC's clock to create scheduled polling events. It's up to you now. With this basic communications infrastructure in place, there's no reason not to partner your PC and Stamps on sophisticated projects.

### Can We Do Both?

Last month, our Stamp program did its processing and served up information without asking. This month, we've gone to the other extreme: the Stamp sits and waits for a command before doing anything. Can we find a happy middle ground?

Yes we can — with caution. We might, for example, create a device that normally runs on its own but has the facility to display and set parameters. In this case, we could use an input to indicate Run or Review mode. When the input (switch) is set to Review, the program would jump to a section that waits for an input query (like Main in this month's program).

When we do this, we'll want to add the timeout parameter to the SERIN function. On a timeout, the program would jump to the Run/Review switch check. If back in Run, the program would go back to its normal operations, otherwise it would continue waiting for some input from the PC.

One of the neat things about using the event-driven serial input of VB is that we don't have to wait around for a specific number of characters to arrive. If you're using the Stamp's programming port of serial communications, be careful not to mix polled commands to the Stamp with spontaneous serial data.

Remember what we just covered: When using the Stamp programming port, the PC's serial transmit pin gets tied back to its serial receive pin. Our VB program deals with this by checking the first character of the buffer for the query character. If we allow the Stamp to spontaneously transmit in a normally polled situation, however, that transmission could take place right in the middle of our polling sequence, corrupting the buffer. And since the Stamp can't receive and transmit serial data at the same time, the incoming data would be missed. Again, be cautious and try not to mix spontaneous and polled communications.

### Comm Control For Everyone

I erred last month when I stated that you had to have the Professional or Enterprise editions of Visual Basic to the MSComm control. There is a work-around for those of you that are using the Learning edition or use a language other than VB.

Serial communications guru Richard Grier has created a free control that you can use with VB (and other programming languages that support ActiveX controls) called XMComm. XMComm uses the MSComm control internally and has all its capabilities. On top of that, it also supports XModem communications for sending files between two computers. Richard has written an excellent book called *Visual Basic Programmer's Guide to Serial Communications.* This book, along with Jan Axelson's *Serial Port Complete* should be on your desk if you intend to do any serious serial-communications programming.

### What's Next?

What I do know is that I don't know for sure except that I'm toying with some Stamp-based robotics ideas. I've got my ideas, but I'd really rather hear yours. Drop me a note and we'll see what we can come up with. Until then, Happy Stamping. **NV**

### Resources:

**Jon Williams**
3718 Valley View Lane, #3040
Irving, TX 75062
(972) 659-9090
jonwms@aol.com

**Parallax**
599 Menlo Drive, Suite 100
Rocklin, CA 95756
(888) 512-1024
www.parallaxinc.com

**Richard Grier**
*Visual Basic Programmer's Guide to Serial Communications*
www.mabry.com

**XMComm control**
ourworld.compuserve.com/homepages/richard_grier

**Jan Axelson**
*Serial Port Complete*
www.lvr.com

Write in 176 on Reader Service Card.

# FET PRINCIPLES AND CIRCUITS

## Part 4

## Field-Effect Transistors

by Ray Marston

*Ray Marston looks at practical VMOS power FET circuits in this final episode of this four-part series.*

For a complete selection of JFETs, Transistors, and MOSFETs, check out Linear Systems on Page 17.

Part 1 of this series explained (among other things) the basic operating principles of those enhancement-mode power-FET devices known as VFETs or VMOS. This final episode of the series takes a deeper look at these devices and shows practical ways of using them.

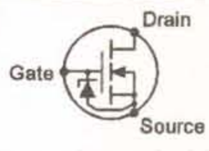



***Figure 1.* Symbol of Siliconix VMOS power FET with integral zener diode gate protection.**

| Device type number | $P_{TOT}$ (max) (W) | $I_D$ (max) (A) | $V_{DS}$ (max) (V) | $V_{GS}$ (max) (V) | $V_{TH}$ (min-max) (V) | $g_m$ (typ) (mmho) | $C_{IN}$ (max) (pF) | $f_T$ (typ) (MHz) |
|---|---|---|---|---|---|---|---|---|
| VN10KM | 1 | 0.5 | 60 | 5 | 0.3 - 2.5 | 200 | 48 | – |
| VN1010 | 1 | 0.5 | 100 | 15 | 2V max | 200 | 48 | – |
| VN48AF | 12.5 | 2 | 40 | 15 | 0.8 - 2 | 250 | 50 | 600 |
| VN66AF | 12.5 | 2 | 60 | 15 | 0.8 - 2 | 250 | 50 | 600 |
| VN88AF | 12.5 | 2 | 80 | 15 | 0.8 - 2 | 250 | 50 | 600 |

***Figure 2.* Major parameters of five popular n-channel Siliconix VMOS power FETs.**

### A VMOS INTRODUCTION

A VFET can, for most practical purposes, be simply regarded as a high-power version of a conventional enhancement-mode MOSFET. The specific form of VFET construction shown in *Figure 17* in Part 1 of this series was pioneered by Siliconix in the mid-1970s, and the devices using this construction are marketed under the trade name 'VMOS power FETs' (Vertically-structured Metal-Oxide Silicon power Field-Effect Transistors). This 'VMOS' name is traditionally associated with the V-shaped groove formed in the structure of the original (1976) versions of the device.

Siliconix VMOS power FETs are probably the best known type of VFETs. They are available as n-channel devices only, and usually incorporate an integral zener diode which gives the gate a high degree of protection against accidental damage; *Figure 1* shows the standard symbol used to represent such a device, and *Figure 2* lists the main characteristics of five of the most popular members of the VMOS family; note in particular the very high maximum operating frequencies of these devices.

Other well-known families of 'Vertically-structured' power MOSFETS are those produced by Hitachi, Supertex, and Farranti, etc. Some of these V-type power MOSFETs are available in both n-channel and p-channel versions and are useful in various high-performance complementary audio power amplifier applications.

### THE VN66AF

The best way to get to know VMOS is to actually 'play' with it, and the readily available Siliconix VN66AF is ideal for this purpose. It is normally housed in a TO202-style plastic-with-metal-tab package with the outline and pin connections shown in *Figure 3*.

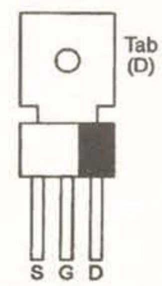



***Figure 3.* Outline and pin connections of the TO202-cased VN66AF power FET.**

*Figure 4* lists the major static and dynamic characteristics of the VN66AF. Points to note here are that the input (gate-to-source) signal must not exceed the unit's 15V zener rating, and that the device has a typical dynamic input capacitance of 50pF. This capacitance dictates the dynamic input impedance of the VN66AF; the static input impedance is of the order of a million megohms. *Figures 5* and *6* show the VN66AF's typical output and saturation characteristics. Note the following specific points from these graphs.

**(1)** The device passes negligible drain current until the gate voltage reaches a threshold value of about 1V; the drain current then increases non-linearity as the gate is varied up to about 4V, at which point the drain current value is about 400mA; the device has a square-law transfer characteristic below 400mA.

**(2)** The device has a highly linear transfer characteristic above 400mA (4V on the gate) and thus offers good results as a low-distortion class-A power amplifier.

FET

**(3)** The drain current is controlled almost entirely by the gate voltage and is almost independent of the drain voltage so long as the device is not saturated. A point not shown in the diagram is that, for a given value of gate voltage, the drain current has a negative temperature coefficient of about 0.7% per °C, so that the drain current decreases as temperature rises. This characteristic gives a fair degree of protection against thermal runaway.

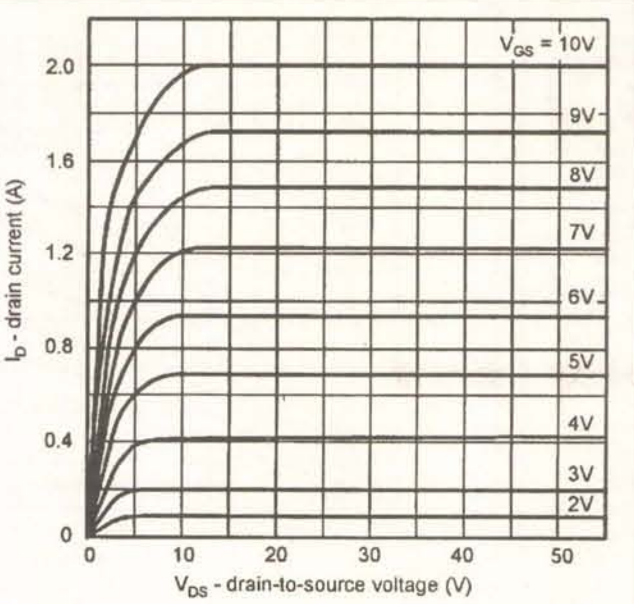



*Figure 5.* **Typical output characteristics of the VN66AF.**

| | | |
|---|---|---|
| STATIC | Max drain-to-source voltage | 60V |
| | Max drain-to-gate voltage | 60V |
| | Max continuous drain current | 2A |
| | Max pulsed drain current | 3A |
| | Max continuous forward gate current | 2mA |
| | Max pulsed forward gate current | 100mA |
| | Max continuous reverse gate current | 100mA |
| | Max reverse gate-to-source (zener) voltage | 15V |
| | Max dissipation at 25°C case temperature | 15W |
| | Gate threshold voltage | 0.8V min, 2.0A typ. |
| | Zero-gate-voltage drain current at 25°C | 10µA max |
| | On-state drain current at $V_{GS}$ = 10V | 1.0A min, 2.0A typ. |
| | Temperature operating and storage range | -40 to +150°C |
| DYNAMIC | Forward transconductance (typical) | 250 mmho |
| | Input capacitance (typical) | 50pF |
| | Reverse transfer capacitance (typical) | 10pF |
| | Common-source output capacitance (typical) | 50pF |
| | Typical switching times, 25V supply, 23R load, 0-10V gate drive from a 50R source: Turn-on delay | 2nS |
| | Rise time | 2nS |
| | Turn-off delay | 2nS |
| | Fall time | 2nS |

*Figure 4.* **Major static and dynamic characteristics of the VN66AF.**

**(4)** When the device is saturated (switched fully on) the drain-to-source path acts as an almost pure resistance with a value controlled by the gate voltage. The resistance is typically 2R0 when 10V is on the gate, and 10R when 2V is on the gate. The device's 'off' resistance is in the order of megohms. These features make the device highly suitable for use as a low-distortion high-speed analog power switch.

## DIGITAL CIRCUITS

VMOS can be used in a wide variety of digital and analog applications. It is delightfully easy to use in digital switching and amplifying applications; *Figure 7* shows the basic connections. The load is wired between the drain and the positive supply rail, and the digital input signal is fed directly to the gate terminal. Switch-off occurs when the input goes below the gate threshold value (typically about 1.2V). The drain ON current is determined by the peak amplitude of the gate signal, as shown in *Figure 5*, unless saturation occurs. In most digital applications, the ON current should be chosen to ensure saturation.

The static input impedance of VMOS is virtually infinite, so zero drive power is needed to maintain the VN66AF in the ON or OFF state. Drive power is, however, needed to switch the device from one state to the other; this power is absorbed in charging or discharging the 50pF input capacitance of the VN66AF.

The rise and fall times of the output of the *Figure 7* circuit are (assuming zero input rise and fall times) determined by the source impedance of the input signal, by the input capacitance and forward transconductance of the VMOS device, and by the value of $R_L$. If $R_L$ is large compared to $R_S$, the VN66AF gives rise and fall times of roughly 0.11nS per ohm of $R_S$ value. Thus, a 100R source impedance gives a 11nS rise or fall time. If $R_L$ is not large compared to $R_S$, these times may be considerably changed.

A point to note when driving the VN66AF in digital applications is that its zener forward and reverse ratings must never be exceeded. Also, because of the very high frequency response of VMOS, the device is prone to unwanted oscillations if its circuitry is poorly designed. Gate leads should be kept short, or be protected with a ferrite bead or a small resistor in series

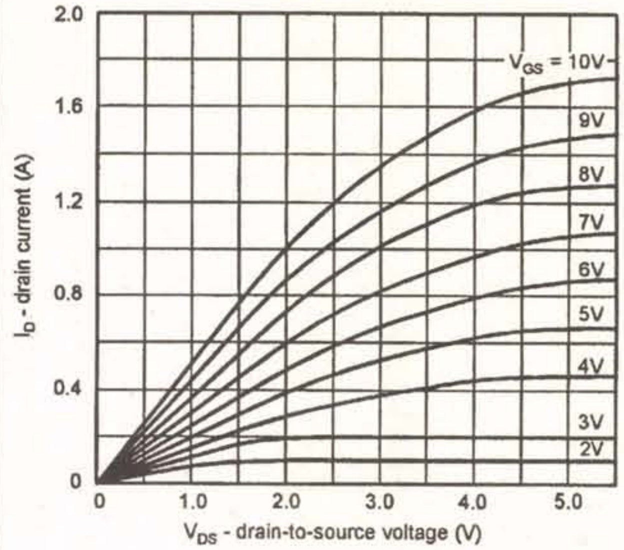



***Figure 6.* Typical saturation characteristics of the VN66AF.**

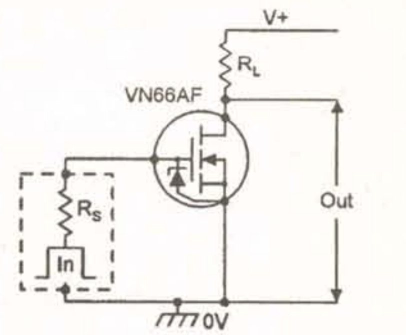



***Figure 7.* Basic VMOS digital switch or amplifier.**

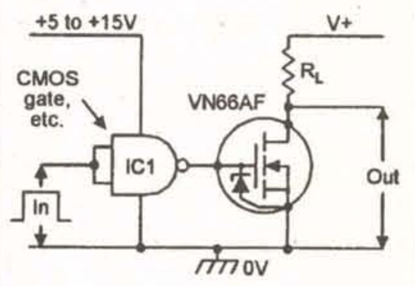



***Figure 8.* Methods of driving VMOS from CMOS.**

with the gate.

VMOS can be interfaced directly to the output of a CMOS IC, as shown in *Figure 8*. Output rise and fall times of about 60nS can be expected, due to the limited output currents available from a single CMOS gate, etc. Rise and fall times can be reduced by driving the VMOS from a number of CMOS gates wired in parallel, or by using a special high-current driver.

VMOS can be interfaced to the output of TTL by using a pull-up resistor on the TTL output, as shown in *Figure 9*. The 5V TTL output of this circuit is sufficient to drive 600mA through a single VN66AF. Higher output currents can be obtained either by wiring a level-shifter stage between the TTL output and the VMOS input, or by wiring a number of VMOS devices in

**FET**

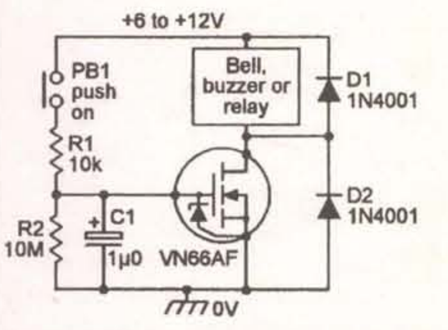
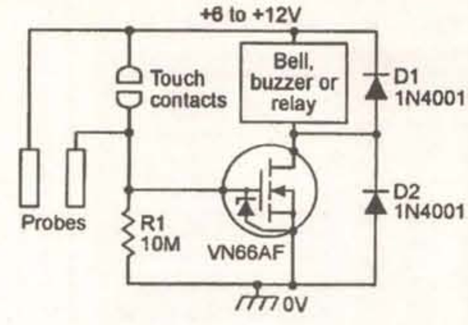



*Figure 13.* Delayed-turn-off power switch.

*Figure 12.* Water- or touch-activated power switch.



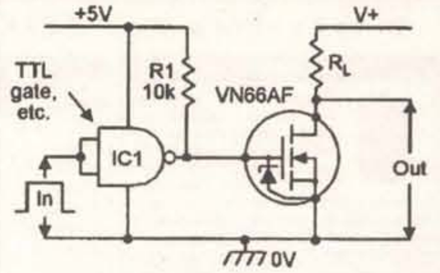




*Figure 9.* Method of driving VMOS from TTL.

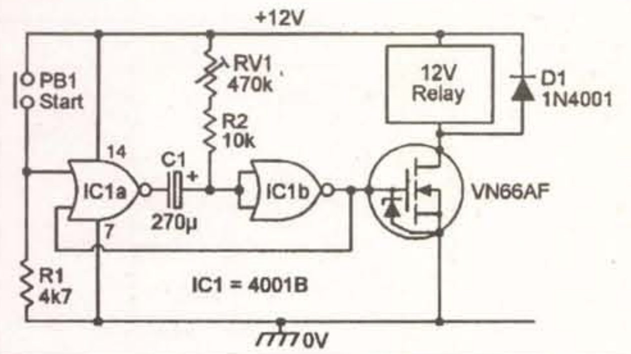



*Figure 14.* Simple relay-output timer circuit.

*Figure 10.* Method of boosting the output of *Figure 9* by driving three VN66AFs in parallel.

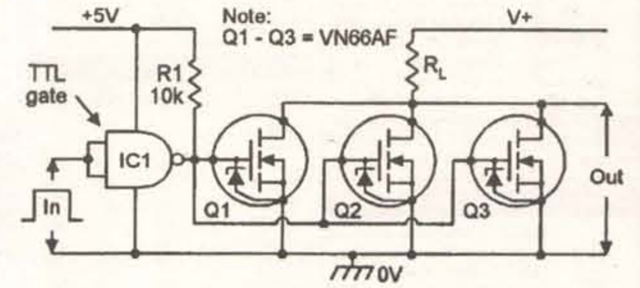
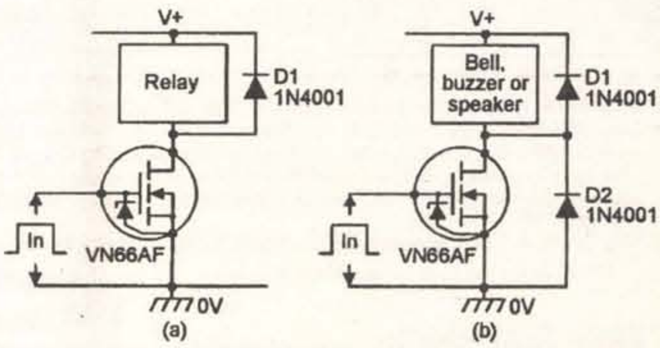



*Figure 11.* If inductive loads such as relays (a) or bells, buzzers, or speakers (b) are used in digital switching circuits, protection diodes must be wired as shown.




parallel, as shown in *Figure 10*.

When using VMOS in digital switching applications, note that if inductive drain loads such as relays, self-interrupting bells or buzzers, or moving-coil speakers are used, clamping diodes must be connected as shown in *Figure 11*, to damp inductive back-EMFs and thus protect the VMOS device against damage.

## SOME DIGITAL DESIGNS

*Figures 12* to *15* show a few simple but useful digital applications of the VN66AF. The water- or touch-activated power switch of *Figure 12* could not be simpler: when the touch contacts and water probes are open, zero volts are on the gate of the VN66AF, so the device passes zero current. When a resistance (zero to 10s of megohms) is placed across the contacts (by contact with skin resistance) or probes (by water contact), a substantial gate voltage is developed by potential divider action and the VN66AF passes a high drain current, thus activating the bell, buzzer, or relay.

In the manually activated delayed-turn-off circuit of *Figure 13*, C1 charges rapidly via R1 when push-button switch PB1 is closed, and discharges slowly via R2 when PB1 is open. The load thus activates as soon as PB1 is closed, but does not deactivate until some 10s of seconds after PB1 is released.

In the simple relay-output timer circuit of *Figure 14*, the VMOS device is driven by the output of a manually triggered monostable or one-shot multivibrator designed around two gates of a 4001B CMOS IC; the relay turns on as soon as PB1 is closed, and then turns off auto-

FET

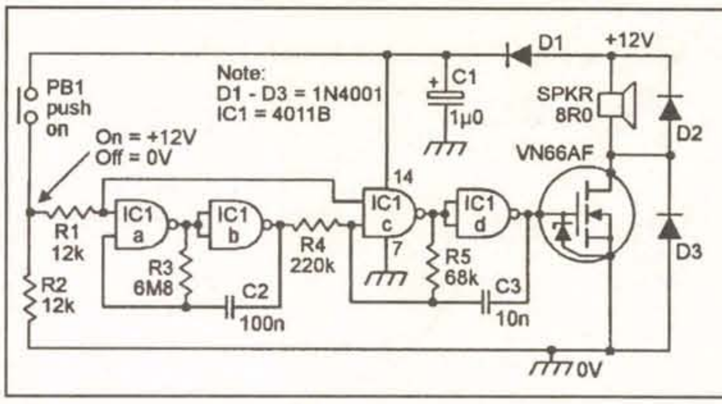



**Figure 15. Warble-tone six watt alarm.**

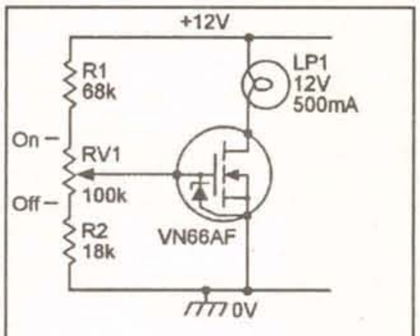



*Figure 16.* **Simple DC lamp dimmer.**

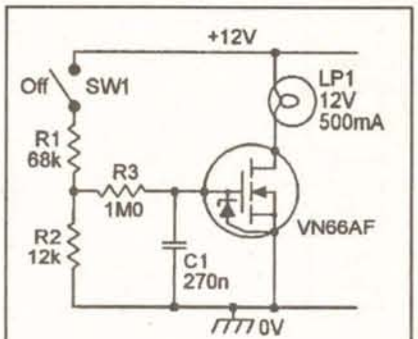



*Figure 17.* **Soft-start lamp switch.**

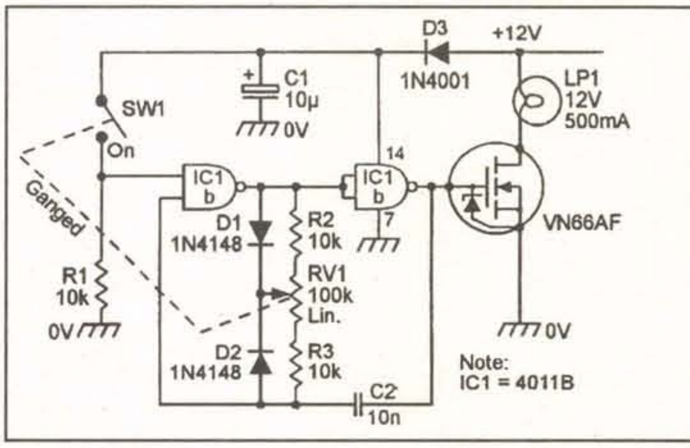



*Figure 18.* **High-efficiency DC lamp dimmer.**

matically again some pre-set 'delay time' later. The delay is variable from a few seconds to a few minutes via RV1.

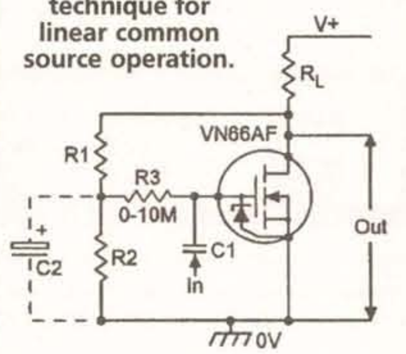
Finally, *Figure 15* shows the practical circuit of an inexpensive but very impressive alarm-call generator that produces a 'dee-dah' sound like that of a British police car siren. The alarm can be turned on by closing PB1 or be feeding a 'high' voltage to the R1-R2 junction. The circuit uses an 8R0 speaker and generates roughly six watts of output power.

## DC LAMP CONTROLLERS

*Figures 16* to *18* show three simple but useful DC lamp controller circuits that can be used to control the brilliance of any 12V lamp with a power rating of up to six watts. A VMOS power FET can, for many purposes, be regarded as a voltage controlled constant-current generator; thus, in *Figure 16*, the VMOS drain current (and thus the lamp brightness) is directly controlled by the variable voltage of RV1's slider. The circuit thus functions as a manual lamp dimmer.

The *Figure 17* circuit is a simple modification of the above design, the action being such that the lamp turns on slowly when the switch is closed as C1 charges up via R3, and turns off slowly when the switch is opened as C1 discharges via R3.

*Figure 19.* **Biasing technique for linear common source operation.**




The *Figure 18* circuit is an efficient 'digital' lamp dimmer which controls the lamp brilliance without causing significant power loss across the VMOS device. The two 4011B CMOS gates form an astable multivibrator with a mark/space ratio that is fully variable from 10:1 to 1:10 via

FET

RV1; its output is fed to the VN66AF gate, and enables the mean lamp brightness to be varied from virtually fully-off to fully-on. In this circuit, the VMOS device is alternately switched fully on and fully off, so power losses are negligible.

## LINEAR CIRCUITS

VMOS power FETs can, when suitably biased, easily be used in either the common source or common drain (voltage follower) linear modes. The voltage gain in the common source mode is equal to the product of $R_L$ and the device's $g_M$ or forward transconductance. In the case of the VN66AF, this gives a voltage gain of 0.25 per ohm of $R_L$ value, i.e., a gain of x4 with a 16R load, or x25 with a 100R load. The voltage gain in the common drain mode is slightly less than unity.

A VMOS power FET can be biased into the linear common source mode by using the standard enhancement-mode MOSFET biasing technique shown in *Figure 19*, in which the R1-R2 potential divider is wired in the drain-to-gate negative feedback loop and sets the quiescent drain voltage at roughly half-supply value, so that maximal signal level swings can be accommodated before clipping occurs.

When – in the *Figure 19* circuit – R3 has a value of zero ohms, the circuit exhibits an input impedance that, because of the AC negative feedback effects, is roughly equal to the parallel values of R1 and R2 divided by the circuit's voltage gain ($R_L$ x $g_M$. If R3 has a finite value, the input impedance is slightly less than the R3 value, unless AC feedback-decoupling capacitor C2 is fitted in place, in which case, the input impedance is slightly greater than the R3 value.

*Figure 20* shows how to bias the VN66AF for common drain (voltage follower) operation. Potential divider R1-R2 sets the VMOS gate at a quiescent value slightly greater than half-supply voltage. When the R3 value is zero, the circuit input impedance is equal to the parallel values of R1 and R2. When the R3 value is finite, the input impedance equals the R3 value plus the parallel R1-R2 values. The input impedance can be raised to a value many times greater than R3 by adding the C2 'bootstrap' capacitor to the circuit.

Finally, *Figure 21* shows a practical example of a VMOS linear application. The circuit is wired as a class-A power amplifier which, because of the excellent linearity of the VN66AF, gives remarkably little distortion for so simple a design. The VN66AF must be mounted on a good heatsink in this application. When the design is used with a purely resistive 8R0 load, the amplifier bandwidth extends up to 10MHz. **NV**

**Figure 21. Simple class-A audio power amplifier gives 1% THD at 1W.**

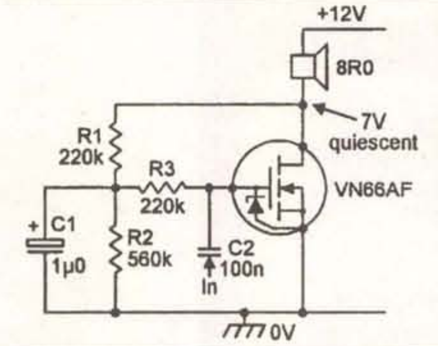
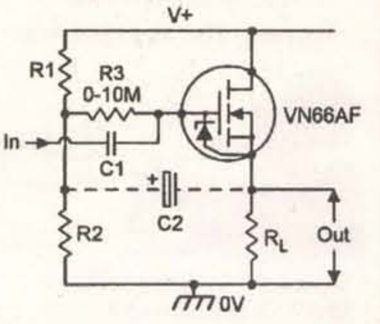



**Figure 20. Biasing techniques for linear common drain (voltage follower) operation.**




FET

*(See ad page 4.)*


# FCC EXAMINATION CREDIT ...

The FCC Report & Order effective April 15, 2000, that revised and simplified the Amateur Radio license classes and examination requirements also grants Examination Credit to various licensees for examinations that they previously passed. This table summarizes the Examination Credit granted under the new FCC rules, and tells which additional Examinations must be passed in order to upgrade to a higher class of license. Please be sure to read definition of "Current" and "Expired" licenses in the notes included here.

| | | Elements Needed to Pass for Upgrade | | | |
|---|---|---|---|---|---|
| **Specific Group Amateurs (Current License Status)** | **Receives Examination Credit for:** | **Upgrade to Technician** | **Upgrade to Technician w/ code credit** | **Upgrade to General Class** | **Upgrade to Extra Class** |
| Current[1] or expired[2] Novice Class operator | Element 1 | | Element 2 | Elements 2 & 3 | Elements 2, 3 & 4 |
| Current FCC-issued Commercial Elements Radiotelegraph operator | Element 1 | | Element 2 | Elements 2 & 3 | Elements 2, 3 & 4 |
| Current Technician Class operator licensed after 2/14/91 | Element 2 | | Element 1 | Elements 1 & 3 | Elements 1, 3 & 4 |
| Current Technician Class operator licensed between 3/22/87 and 2/14/91 | Elements 1 & 2 | | | Element 3 | Elements 3 & 4 |
| Expired Technician Class operator licensed after 2/14/91 | Element 1 | | Element 2 | Elements 2 & 3 | Elements 2, 3 & 4 |
| Current Technician-Plus operator licensed after 2/14/91 | Elements 1 & 2 | | | Element 3 | Elements 3 & 4 |
| Current Technician Class operator licensed on or before 3/21/87 | Elements 1, 2 & 3 | | | Now qualifies as a General Class operator | Element 4 |
| Expired Technician Class operator licensed on or before 3/21/97 | Elements 1 & 3 | | | Element 2 | Elements 2 & 4 |
| Current General or Advanced Class operator | Elements 1, 2 & 3 | | | | Element 4 |
| Expired Technician-Plus, General, Advanced, or Extra Class operator | No Credit | Element 2 | Elements 1 & 2 | Elements 1, 2 & 3 | Elements 1, 2, 3 & 4 |

**NOTES:**
1. A "Current" license is one that is not expired, or is within the FCC's two-year grace period for renewal.
2. An "Expired" license is one that is expired for two or more years and is beyond the FCC grace period for renewal.

An applicant must provide reasonable evidence that he/she was licensed as required to obtain the exam credit. This proof can be a copy of your old license, a photocopy of an old Callbook page, or any other evidence of your prior license status. The W5YI-VEC can assist applicants who wish to research old licensing information. There is a small charge for this service. Call 817-860-3800 if you need help.

*Source: W5YI-VEC*

Questions & Answers

# TECH FORUM

This is a READER TO READER Column. All questions AND answers will be provided by *Nuts & Volts readers* and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. All questions submitted are subject to editing and will be published on a space available basis if deemed suitable to the publisher. All answers are submitted by readers and *NO GUARANTEES WHATSOEVER* are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

## QUESTIONS

Send all material to **Nuts & Volts Magazine**, 430 Princeland Court, Corona, CA 92879, OR fax to (909) 371-3052, OR E-Mail to **forum@nutsvolts.com**

Is there a way to check components in small power supplier (electronic typewriters) without removing components? Seems like theory discussion doesn't cover troubleshooting.

**#8001** **Richard Budrow**
**Olympia, WA**

Does anyone have a full service (POP3/SMTP) bios tweak for the Mail Station?

**#8002** **John Williams**
**Hayward, CA**

In answer to #10011, Jan. '00 regarding a schematic/SW to allow the PC via its parallel port to connect to a GPIB device. The reply cited "plotgpib.zip" a shareware product.

I have looked many places in a lot of shareware cites (shareware.com, tucows.com, etc.), and have come up empty.

Can someone please come up with a more definite location for this software?

**#8003** **John Hudak**
**via Internet**

I work with AVR microcontrollers which are being clocked with an external crystal or oscillator, typically at 4 MHz. I would like to be able to change the clock rate (slower) via an external circuit triggered either by an outside event or by the micro itself.

Ideally, the circuit to do this would be driven by a single clock source and send out as clean a pulse during switching as the source itself (i.e., no chopped pulses or shortened periods).

Dropping a few clocks during switching to keep things clean would not be problematic. I am remembering the turbo switches on PCs not so long ago, but I hope to find a simple (low-component count) solution.

There are several applications I have in mind for this, one of which is to enable testing of this fast micro with a PC-based logic analyzer.

**#8004** **Kurt Stevens**
**via Internet**

I have an old DOS graphics program that uses printer control codes to control an NEC PC-8027 printer. This application was written for a DEC PDP-11 (RSX-11M), which runs from DOS via a Strobe Data Osprey emulation board. The application was written by Minato (Japanese tester company), which has since been purchased by Ando. The printer is no longer supported by NEC and there's no new source code available for the program. Of course, it's a program that I still need to use. Is there a hardware or software means of translating the printer control codes from this printer to a more modern one? I thought of using an EPROM decoder or a TSR patch.

**#8005** **Patrick McComas**
**pkm@cypress.com**

I have several 640 x 480 graphical LCD displays and I can't seem to find any controller ICs or chip sets to allow me to control them.

I'd like to be able to send serial data to it and have it displayed for an engine monitor.

I would rather use something that already exists rather than take all the time to design, build, and debug a one-of-a-kind controller.

**#8006** **Norm Doty**
**Hollywood, FL**

I am desperately looking for a way to control a residential bath fan/light unit. It is now wired on one switch. I am seeking a way to control them independently while using the existing wiring which is two wires (only one load wire).

I have seen such a unit for paddle fans, but I can't locate one for exhaust fans. None of the major electrical manufacturers I contacted were any help.

**#8007** **via Internet**

Does anyone have the pinout for a miniature camera made by TVX International? The model is TVX04-IMAGER PCA. It looks like an 11-pin push-on type of connector. The unit was sold by Goldmine Electronics.

**#8008** **Roy E. Kneale**
**vai Internet**

LM3909 is an LED blinker chip, it is being discontinued. Jameco sells them for about $5.00 a piece now. Does anyone know of any replacement LED blinker chip that sells for a reasonable price? RadioShack no longer carries LM3909. (I do not have a computer.)

**#8009** **Sumeth Kongsuwan**
**Belvidere, IL**

I would like to adapt an LP4081 Ricoh printer with a 50-pin connector — similar to Apple — to my PC with a 25-pin connector. Is there a way to do this?

Spec. info parallel (Centronics) and serial RS 232C adapter, comes installed in printer.

**#80010** **Thomas Bristol**

I recently acquired a surplus HP 7046B plotter that still works well. However, it only responds to analog voltage inputs. I would like to connect it to a PC printer port through a suitable interface device that is also compatable with HPGL software.

Does such a device exist or how would I go about building one?

**#80011** **Bill Hawes**
**Kirkland, WA**

I have a problem with a small circuit in a Shop Light. It is made by Lifelite, model #8040. It has a small circuit after the transformer in the line to each light. I know the light is only $7.00 to replace, but I would like to fix the one I have, although it may cost more to fix than to replace.

There is a semiconductor between the base (I think) of the TO92 transistor and a resistor on that little board. I would like to know what it is. Also, I'd like to know what type (NPN, PNP) the transistor is. It is marked "Q102."

**#80012** **Burton Daggett**
**Shelton, WA**

I am an older technician recently assigned to service EEPROM-based equipment. What is the best way to learn EEPROM repair technology? Do BASIC Stamps or PICs have any relevance to commercial equipment?

I prefer the non-math functional analysis approach to troubleshooting.

**#80013** **Bob Kramer**
**Aurora, IL**

I have a Rustrak model 288 DC chart recorder that I would like to have measure a variety of DC input voltages (and, if possible, AC). I believe there were attachment kits for this purpose sold, but I've never been able to get a response from the manufacturer about them.

The power source for this is line voltage, but the input to the chart recorder marker must be DC. I have determined that a 1-1/2V battery in series with a 2200Ω resistor will give about a 60% deflection on the chart which was the pointer of the meter as a marker.

I already know I can use a variety of resistors or a variable pot to measure DC voltages, but I also would like

### ANSWER INFO

- Include the question number that appears directly below the question you are responding to.
- Payment of $25.00 will be sent if your answer is printed. Be sure to include your mailing address if responding by E-Mail.
- In most cases, only one answer per question will be printed.
- Your name, city, state, and E-Mail address, (if submitted by E-Mail), will be printed in the magazine, unless you notify us otherwise with your submission.
- The question number and a short summary of the original question will be printed above the answer.
- Unanswered questions from a past issue may still be responded to.
- Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

### QUESTION INFO

**TO BE CONSIDERED FOR PUBLICATION**

All questions should relate to one or more of the following:

1) Circuit Design 3) Problem Solving
2) Electronic Theory 4) Other Similar Topics

**INFORMATION/RESTRICTIONS**

- No questions will be accepted that offer equipment for sale or equipment wanted to buy.
- Selected questions will be printed one time on a space available basis.
- Questions may be subject to editing.

**HELPFUL HINTS**

- Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
- Write legibly (or type). If we can't read it, we'll throw it away.
- Include your Name, Address and Phone Number. Only your name will be published with the question, but we may need to contact you.

to be able to measure 105-125 VAC, if this is possible.

The only other things I know about this, is that the meter is rated 1.0 mA and the chart drive has an internal resistance of 80Ω. (Chart width for 0-100 is 2-1/4 inches.)

**#80014** **Richard Flaws**
**Oswego, IL**

How can I access the Internet over my Motorola bagphone?

**#80015** **Steve Lafontaine**
**via Internet**

I have an odd IBM power supply for an IBM 300GL socket 7 system. It has two connectors of AT design, plus two additional three-volt connectors of six pins each. It also has two three-pin mini connectors. The power supply has no on/off switch, so I assume it's of the same principle as an ATX supply where the power switch is through the motherboard. I need more of these supplies, so any information on them or how to convert an ATX to one would be greatly appreciated.

**#80016** **Tyler Graff**
**tgraff@mindspring.com**

# ANSWERS

**ANSWER TO #7002 - JULY 2000**

*I have several Icom M80 marine VHF radios with a failed microprocessor. Icom says this chip is no longer available. It's a Motorola MC146805G2. I need a supplier for this chip or a substitute.*

In response to Earl Walton's (and others) question regarding locating suppliers of chips, one website that provides a large database is FindChips.com @ **http://www.findchips.com/**

It is a very useful site that should be bookmarked for future use.

**Barry Tuttleman**
**Carson City, NV**

**ANSWER TO #7008 - JULY 2000**

*I want to add an RS-485 network to the 68HC11. I am looking at SPI communication on the MCU and either a MAX483 or a SN75176A bus driver. What I need is a schematic of how to connect them and some sample software.*

Get my book *Digital and Computer Projects* by Robert J. Davis, available on several Internet book sites. It has plans for a multi drop 68HC11F1 controller system that is used for a campus wide energy management system. It supports up to 16 devices, but with software modifications, many more could be added.

There is software listings in Basic for a controlling PC and Machine language for the 68HC11 controllers. It does not support bidirectional communication over the same pair due to limitations of Basic on the PC. I understand this can be accomplished in hardware, however. I was amazed that no one seems to make a ready-made controller board for this application.

**Bob Davis**
**via Internet**

**ANSWER TO #70011 - JULY 2000**

*I want to put strobe lights in the rear turn signals on my truck so that when I stop on the side of the road to aid someone, they will flash very brightly.*

*I want to build a circuit that will flash a strobe alternately in a back and forth motion.*

*It is a '98 Nissan Frontier with yellow turn/hazard lights.*

*I would like to drill a hole in the housing and install the strobes as secondary flashers so that the turn and original lights still operate normally.*

Galls, Inc., is a supplier for equipment for police, fire, and EMS departments. They sell the strobes that you are looking for. You can request a catalog at **http://www.galls.com/** or by calling **1-800-477-7766**.

You may need to check with your local authorities regarding flashing lights on your vehicles, but since you are using only yellow colored strobes you should not have a problem.

**Michael Weber**
**Mifflinburg, PA**

**ANSWER TO #7004 - JULY 2000**

*I have one of the old Atari calculators designed to be used without batteries. But under room light, it does not work very well. I would like to replace the cell with a battery, but I'm not sure where to start. The model is the CC1200 folding calculator.*

First, you must determine the output voltage of the solar cell. Carefully disassemble the calculator, measure the voltage across the solar cell when exposed to sunlight and note the polarity of the voltage.

Today's calculators operate off a single cell (1.5V). This calculator being old may require two or more cells (3V or more). Most likely you would need 3V.

You should be able to use a small button type 3V lithium battery with solder tabs, which you can buy at any RadioShack. Simply cut off the original solar cell, match the polarity and solder the wires to the new battery. The current draw from the battery is very low so it should not require an external on/off switch.

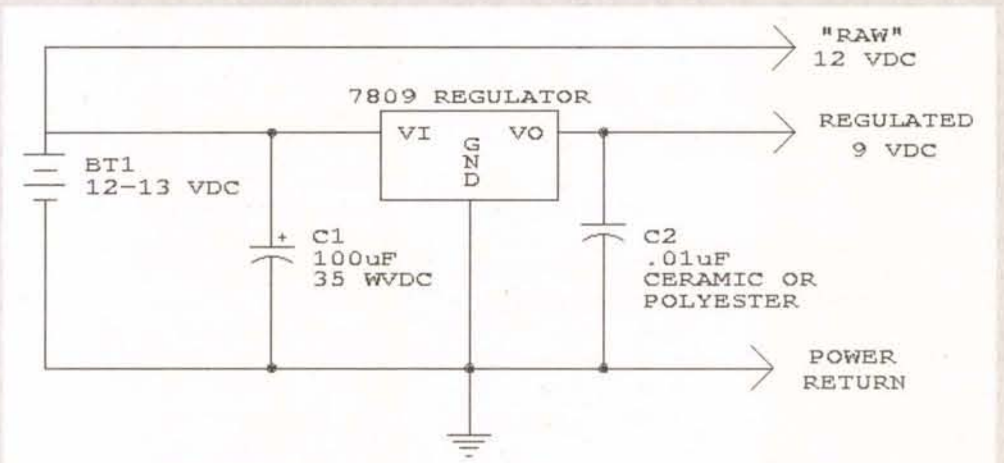
**Haim Sandel**
**Scottsdale, AZ**

**ANSWERS TO #7007 - JULY 2000**

*I have a video transmitter that's operating on a 12 VDC at 300 mA wall adaptor, and a CCD camera, working on a 9V battery. I would like to operate both devices from a portable and compact (12 VDC) battery pack (the smaller, the better), for at least an hour.*

*Any suggestions and/or ideas on how to split the power supply for both devices, each having different power requirements?*

**#1** Please refer to the attached schematic for a "power distribution system" that might suit your needs.




"Main" power is derived from "any old" gates-type sealed lead-acid 12V gelcell (or similar "high-capacity" 13V NiCad battery pack). Assuming the camera doesn't eat more than 1 amp, the 7809 three-terminal regulator shouldn't overheat. Nonetheless, make sure you attach the regulator to a suitable heatsink and insulate ALL wires/terminals to prevent unwanted short circuits.

It can be built on perfboard using "point-to-point" wiring — nothing is critical. However, make sure you have C2 (the .01uF bypass cap — DO NOT OMIT!) cap as close as possible to the regulator AND, depending on the length of cable from the regulator assembly, you may need another electrolytic paralleling C2.

**Ken Simmons**
**Auburn, WA**

**#2** The easiest, least expensive, and perhaps the best way to solve your split power supply problem is with two linear voltage regulators.

Part number LM 7809 (NTE 1910) and LM 7812 (NTE 966) are two inexpensive voltage regulators that recommend, but not require, two external capacitors to stabilize the ripple caused by regulation; and between the four capacitors and the two regulators, should come to a grand total of less than $5.00, depending on where you shop.

At your low power requirements, the TO-220 package doesn't require a heatsink, but with a heatsink attached, they can handle loads as high as one amp each.

These regulators are simple to use and when viewing the chip like a book, and reading its numbers upright from left to right, the "power in" pin is at the left and the "power out" pin is at the right, with the center pin being ground.

On each chip it is recommended that you attach a .1 to 100 uFd to the input pin #1, and on the power out pin, you attach a capacitor with a value of .33 to 100 mFd (or multiples), and your circuit is complete.

The different values given here come from different schools of thought, but any capacitor within those values will suppress ripple. However, as I have found, you may need to experiment with your camera more so than your transmitter in regards to these capacitors. A regulator circuit that works perfectly well on a monitor, a different camera, or other devices might show lines of ripple in some C-MOS or other type CCD cameras.

If your transmitter requires more than one amp (value not mentioned), then there are bigger versions of the LM 7812 that will meet your needs such as the NTE 1912 @ 3 amps, or the NTE 933 @ 5 amps. And although these come in a different TO-5 package designed to deliver more current, they are still simple three-lead regulators.

Most of these chips when purchased over the counter from places like RadioShack and others, come with a setup diagram explaining all of your questions.

Other methods of split power supplies include switching regulators, buck/boost regulators and simple resistor voltage dividers, as well as a whole slew of other devices. But for the money, simplicity, and thermal shutdown that these regulators offer, you can't go wrong.

**Chris**
**Bieber, CA**

# TECH FORUM

### ANSWERS TO #7003 - JULY 2000

*I am in the computer field and many times after moving a monitor, it has purple splotches on the screen. The built-in degausser just doesn't do the trick. I spoke with an "old timer" in the TV business and he said you can make a degausser.*

*Does anyone know how to do this as it appears to be a coil of lamp cord and a switch.*

**#1** A simple manual degaussing device can be built from removing the degaussing coil from an old monitor and connecting it to a doorbell transformer. A 12- to 24-volt transformer is usually needed because degaussing coils are not designed to operate directly off 120 volts.

The coil can be found in an old monitor by looking for a coil wrapped in black tape near the front of the picture tube. Generally, it is as big as the outside circumference of the picture tube. In some cases, you need to remove the picture tube to get at the coil. It should have a two-pin plug that plugs into the power supply of the monitor.

This coil can be used to degauss the monitor by wavering it around the front of the monitor then slowly pulling it away before removing power. Do not leave it plugged in too long as the coil may get hot and the doorbell transformer may also overheat.

**Bob Davis**
**via Internet**

**#2** Here is a "hot tip" from an old TV repairman. If you own a high-powered soldering gun (like the Weller 240 watt models) with a power transformer, you already own a pretty good degaussing tool. Turn the gun on while a foot or so away from the monitor. Then move the gun around the perimeter of the tube a few times and then slowly back off to a foot or so away from the monitor before turning it off. Remember, the tip on the gun is also a hot one.

**John Montalbano**
**via Internet**

### ANSWERS TO #6004 - JUNE 2000

*I am interested in scanning pixel values from my color webcam. I am theorizing that the webcam writes values to 'video' memory which are used to generate the picture on the screen. My missing link is the program to read this value while the camera is running in the 'background.'*

*Is this possible? Is my theorizing correct? What programming language is recommended? How do I run both camera and program at the same time?*

**#1** Your assumption is correct that whatever is displayed on the screen is represented as a value in memory that can be queried. Any programming language from Assembly to Visual Basic could be used to write a program to acquire the values.

Here is the link to a program that will show you the RGB value of any color you point to on the screen. It sounds like just what you are asking for. It runs while any other program is running. **www.tucows.com/color95.html#apicker95**

**David Wolff**
**San Jose, CA**

**#2** Possible: Yes. Theory: Close:

The program reads from the web-cam and places the data wherever.

In many Internet Web-Com systems, single shots are stuffed in a file (Disk or REM-Disk) that the web server software reads to send to requesters. Your existing software should be able to grab single frames to disk.

Language: C or Assembly. If you want full motion, then try to minimize use of OOP code.

How to run: You need the interface info to access the camera driver. Then you can put the data wherever you want.

**Jèrel D. Arbaugh**
**via Internet**

# reader FeedBack

*Continued from page 13*

## More On Telephone Busy Lights

Dear Nuts & Volts:

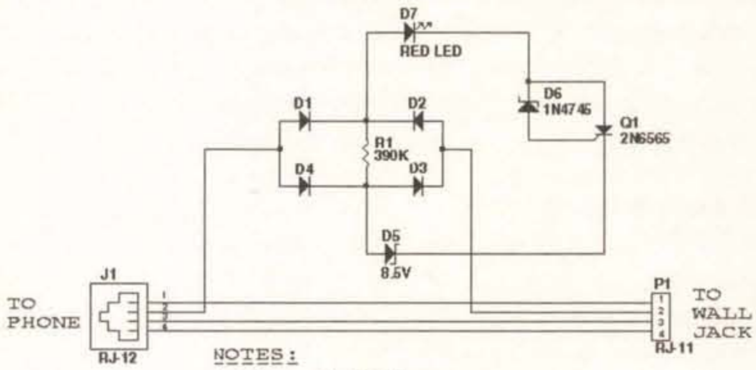
I read with much interest the "Reader Feedback" letters about Telephone Busy lights. While the suggestions are useful, I think I have a much simpler alternative that does not require any power source (i.e., batteries) other than the phone line itself.

Attached is the schematic of a commercial "Phone Line Blocker" that was given to me many years ago (I don't think such a device is currently available any more). Not only does it indicate when the line is in use (the LED), when attached to "auxiliary" phone devices that share one line, it will totally block those "auxiliary" phones when a "master" phone or modem is in use.

In other words, no more modem interruptions while indicating to the "other phones" that the line is currently in use. While "any old LED" can be used, one can certainly use a "blinking" or "high-brightness" LED if one desires.

There is one caveat to be aware of: the "master" telephone device (i.e., modem or "main" phone) ** MUST NOT ** have a blocker on its line! In other words, only the "auxiliary" devices can have the blocker installed. However, if the "master" device is not in use, the "auxiliary" device(s) can use the phone, one at a time (i.e., no "eavesdropping") as long as the "master" ("unprotected" device) is not taken off-hook. Here's a typical use:

```
Phone in ---------------------------> Modem
               |
               |---- blocker -------> Phone device #1
               |---- blocker -------> Phone device #2
               |---- blocker -------> Phone device #n
```




NOTES:
- Q1 - 2N6565
- D1-D4: 1N4002
- D5 - 8.5V ZENER
- D6 - 1N4745
- D7 - "ANY OLD" RED LED
- WIRE CODING: 1 - BLACK
  2 - GREEN
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**Ken Simmons**
**Auburn, WA**

# ADVERTISER INDEX



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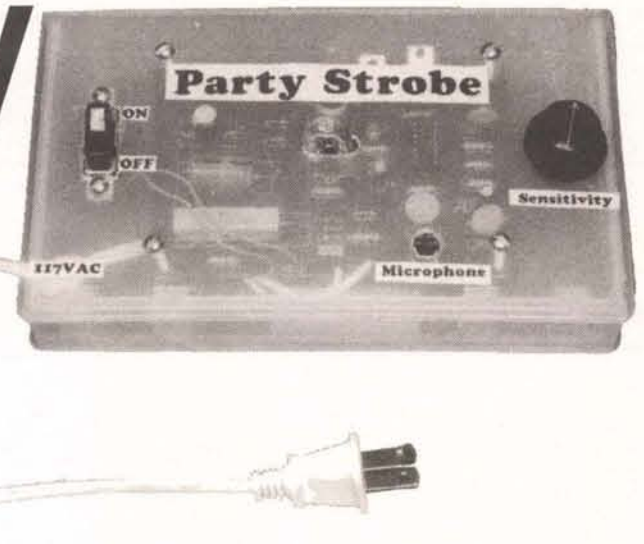
# Product/Category INDEX

Find what you need FAST

by Fred Blechman and David McDonald

# Build a Party Strobe Light




**Unlike most strobe units used at parties, the Party Strobe is sound-sensitive using a built-in microphone. The strobe flashes with the beat of the music! Designed by David McDonald and powered by the AC line, it uses no batteries, and can be built from a $24.90 kit or from scratch.**

In the '70s, '80s, and still in the '90s, discotheques ("discos") were extremely popular. Loud, pounding music with flashing vari-colored lights and rotating mirrored balls reflecting over crowded, jiggling dancers was the norm.

The flashing vari-colored lighting was created by stroboscopic ("strobe") lights with colored lenses. The sophistication of some of these devices is described in an advertisement for a commercial "Dazzling Strobe Bar." It reads: "Pump up the volume and turn down the lights.

Let the alternating color flashes of this dramatic strobe bar get the dance floor in groove with the tunes. It has seven different lighting effects, a full-function remote, and a built-in microphone that makes the lights strobe with the beat of the music."

These days many disco parties are held in the home and are less elaborate. The single "Party Strobe Light" described here, together with a rotating mirrored ball and some loud music, should be all that's needed for a home disco party.

A complete kit of parts, including an etched, drilled, and silkscreened printed circuit board, is available for $24.90. Some of the more difficult-to-find parts and the printed circuit board are offered separately if you have some of the common parts.

## Circuit Description — Power Supply

The schematic of the Party Strobe Light is shown in Figure 1. The circuit may be considered as having three main parts working together: Power Supply, Audio Amplifier, and Xenon Strobe. When P1 is plugged into 110 VAC and switch S1 is closed, power is supplied separately to the amplifier and Xenon sections.

The incoming AC line power is directed to the amplifier section through diode D3. This only allows the pulsating positive cycles of the line power to be filtered (smoothed) by a pi-filter consisting of electrolytic capacitor C4, resistor R4, and electrolytic capacitor C5.

The filtered DC voltage at C4 is about 165 volts. The values of R4 and R6 create a voltage divider, so the filtered DC voltage at C5 — which powers the amplifier circuit — is about 10 volts.

Power to the Xenon strobe portion of the circuit is divided into two parts. A high voltage of about 320 volts is provided through a "voltage doubler" circuit. Looking at Figure 1, when the positive half of the 110 VAC cycle (about 160 volts peak) appears at the lower contact of the AC plug, current flows through switch S1 and diode D1, charging electrolytic capacitor C1 over a short period of time to 160 volts. Diode D2 is non-conductive during this time since both the top and bottom of electrolytic capacitor C2 are at positive voltage.

During the other half of the cycle, D2 conducts and C2 becomes charged with the AC peak voltage plus the voltage in C1, for a total of about 320 volts (depending on the actual AC voltage).

Resistor R1 is used to limit the surge current during the initial cycle, since C1 and C2 look like a short-circuited load. Also, during rapid flash sequences when sound is detected, resistor R1 is used to limit the actual charging of C1 to 125 volts and C2 to 250 volts — the rated Xenon flash tube voltage — since C1 and C2 don't have time to fully charge between flashes.

Also, positive half-cycles pass through R1 and current limiting resistor R2 to the anode of silicon-controlled rectifier Q1 in the trigger circuit, as we'll see later.

In summary, with relatively few parts, the 110 VAC is converted into about 10 VDC to supply the amplifier circuit, into about 250 VDC to supply the Xenon flash tube, and voltage to power the trigger circuit.

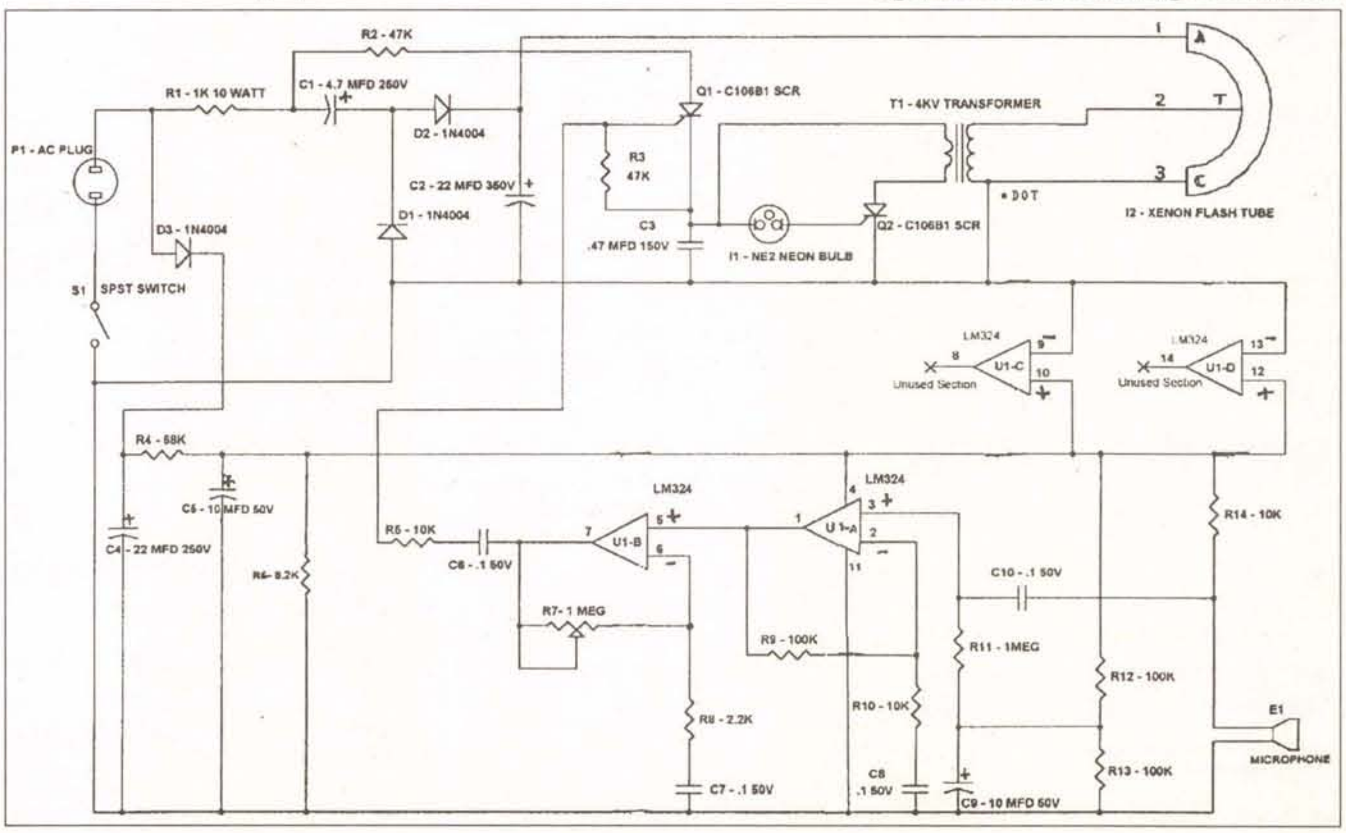
## Circuit Description — Audio Amplifier

Looking at the lower portion of the Figure 1 schematic, the audio amplifier consists of electret microphone E1 and two sections of U1, an LM324 quad op-amp integrated circuit, together with the associated resistors, capacitors, and potentiometer. Only sections A and B of U1 are used; sections C and D are intentionally grounded to prevent oscillation or interference.

Resistor R14 provides a path and the biasing voltage required for E1. Sound waves received at E1 generate small AC voltages that add and subtract from the bias voltage, and are carried through capacitor C10 to the (+) non-inverting input, pin 3, of U1-A.

Resistors R12 and R13 form a voltage divider, creating a five-volt bias voltage (one-half the supply voltage) to U1-A so that U1-A may then amplify both

**Figure 1: Party Strobe Light Schematic**



# Parts List

Note: The relatively hard-to-find parts marked with an asterisk (*) are available from Hobbytron (see SOURCE below).

* C1 - 4.7uF 250-volt axial electrolytic capacitor
* C2 - 22uF 350-volt axial electrolytic capacitor
* C3 - 0.47uF 200-volt axial capacitor
* C4 - 22uF 250-volt axial electrolytic capacitor
(Note: See SOURCE for Capacitor Set of C1-C4)
C5, C9 - 10uF 50-volt radial electrolytic capacitor
C6, C7, C8, C10 - 0.1uF 50-volt disc capacitor
D1, D2, D3 - 1N4004 silicon power diode
* E1 - Electret microphone (GK09002 $1.20)
* I1 - NE2 neon bulb (GK10004 $0.35)
* I2 - 5-watt xenon flash tube (GK10001 $3.85)
* P1 - AC line cord with plug (GK12001 $1.25)
* Q1, Q2 - SCR C106B1 (GK13001 $1.00 each)
* R1 - 1K 10-watt resistor (GK48001 $0.79)
R2, R3 - 47K 1/2-watt resistor
R4 - 68K 1/2-watt resistor
R5, R10, R14 - 10K 1/2-watt resistor
R6 - 8.2K 1/2-watt resistor
* R7 - 1 megohm 1/2-watt potentiometer (GK33010 $1.25)
R8 - 2.2K 1/2-watt resistor
R9, R12, R13 - 100K 1/2-watt resistor
R11 - 1 megohm 1/2-watt resistor
* S1 - SPST slide switch (GK25001 $0.65)
* T1 - 4,000 volt trigger transformer (GK23010 $1.50)
* U1 - LM324 quad op amp integrated circuit (GK14002 $0.90)
* Circuit Board - GK#7785 $8.95
* Capacitor Set = C1, C2, C2, C4 (GK39000 $6.95)

**SOURCE:**
A complete kit of parts (Kit #9985 for $24.90), or the parts identified with an asterisk (*) above, can be ordered from HobbyTron, Inc., 1185 South 1480 West, Orem, UT 84058. 1-888-606-TRON (8766), Fax 1-800-470-1606 or local number 801-221-9822, Fax 801-221-9280. Shipping and handling UPS Ground in the USA is $6.95 per order. Sales tax for Utah residents is 6.25 percent. The E-Mail address is garyg@itsnet.com, and the website is HobbyTron.com.

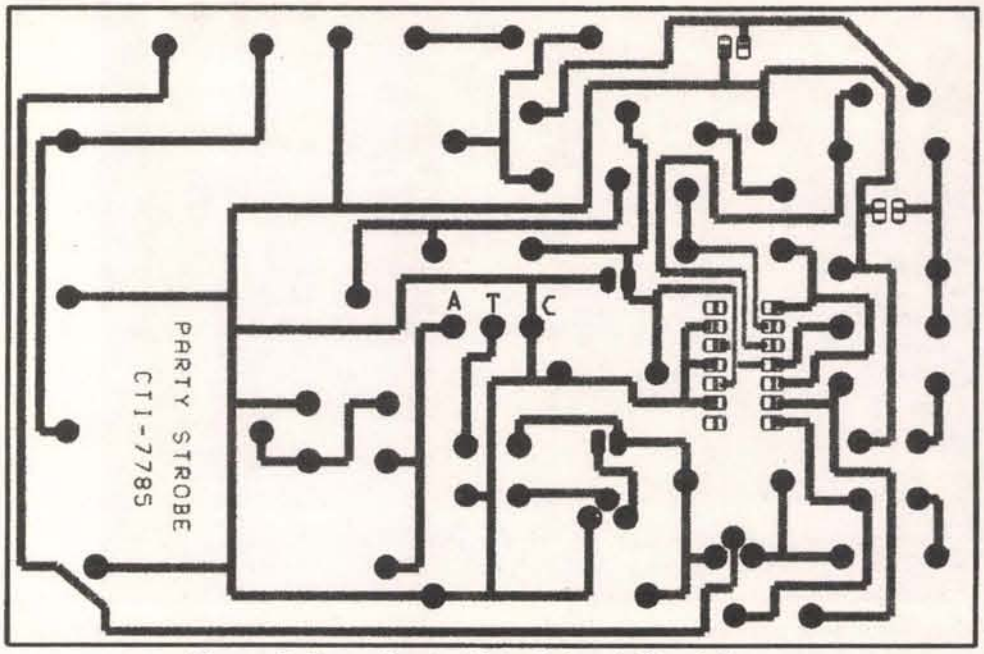



**Figure 2: Party Strobe Light Printed Circuit Traces**

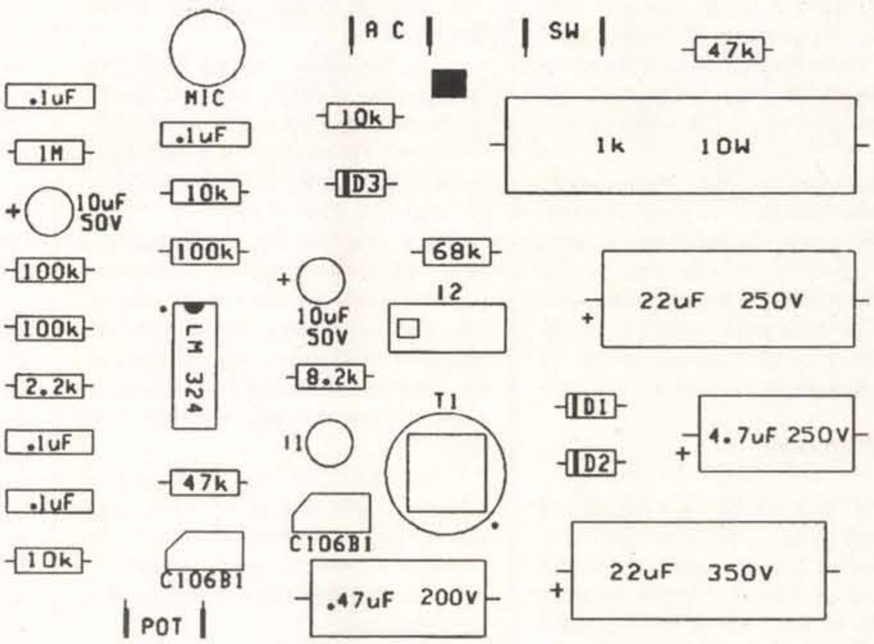



**Figure 3: Party Strobe Light Parts Layout**

positive-going and negative-going signals. Electrolytic capacitor C9 filters this voltage further to eliminate any 60-cycle or line interference. Resistor R11 delivers the bias voltage to U1-A, and is of a high enough value so as to prevent the microphone signal from being shunted to ground through C9.

The voltage gain of U1-A is controlled by resistors R9 and R10. The formula is: Voltage Gain = 1+(R9/R10) = 1+(100K/10K) = 11. Capacitor C8 bypasses unwanted noise.

The output of U1-A at pin 1 goes directly to the (+) non-inverting input, pin 5, of U1-B. The gain of U1-B is controlled by the values of potentiometer R7 and resistor R8, with capacitor C7 bypassing unwanted noise.

However, since R7 is variable — from 0 to 1 megohm — and the voltage gain equals 1+(R7/R8), the voltage gain can vary from 1 to over 450. The total gain of the amplifier (U1-A times U1-B), therefore, varies from 11 to 4,950 (11 times 450).

The output of U1-B at pin 7 is sent through capacitor C6 and resistor R5 to the gate of Q1. More on that soon.

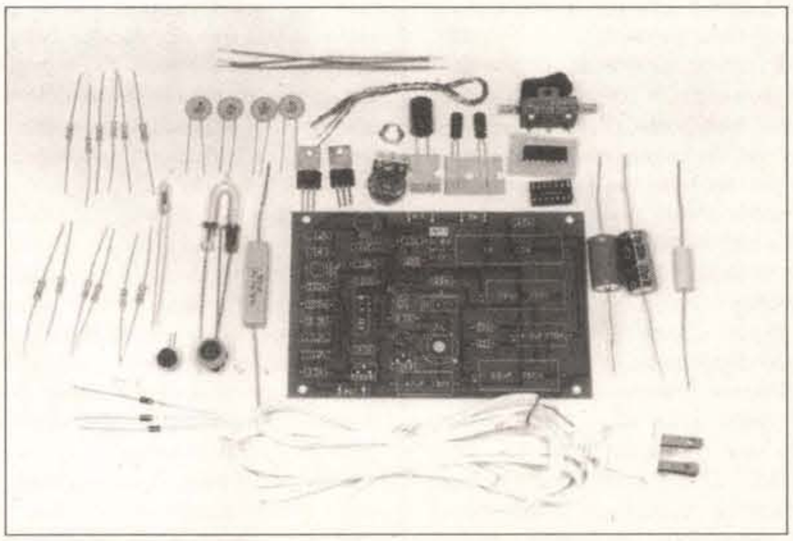
## Circuit Description — Xenon Strobe

In order for xenon tube I2 to flash — igniting the gas in the tube to emit a white light — it requires at least 200 volts DC between the anode (pin 1) and cathode (pin 3), as well as a "trigger" voltage (pin 2) of approximately 4,000 volts DC.

When P1 is plugged into 110 VAC and S1 is closed, the voltage doubler circuit described earlier causes as much as about 320 volts DC to build up between the positive anode and the grounded cathode of I2.

But how do we create 4,000 volts DC for the trigger? Look again at Figure 1, and locate Q1, the silicon controlled rectifier (SCR). The symbol represents three terminals. The top of the arrow is the anode, the line at the point of the arrow is the cathode, and the line at an angle at the cathode is the gate.

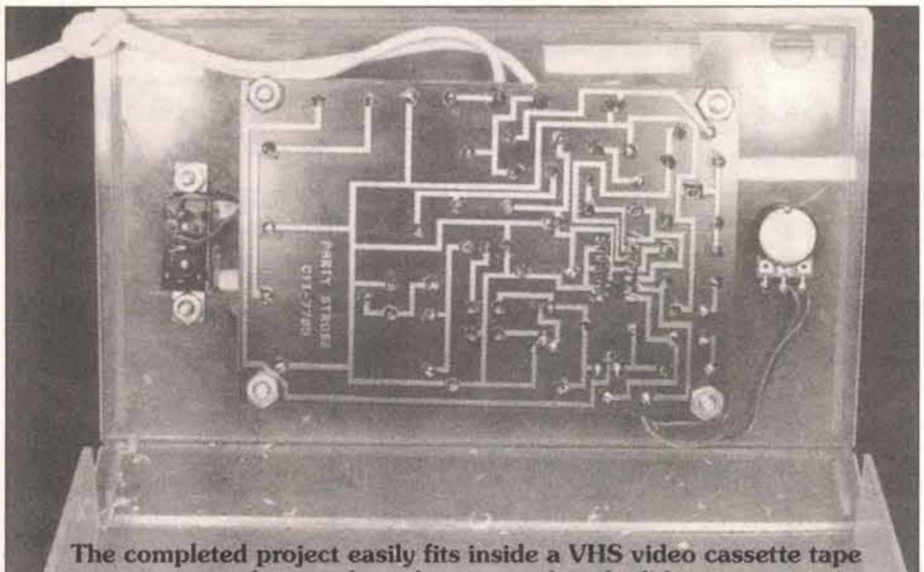
The SCR differs from a regular silicon rectifier in that it will not conduct (anode to cathode) until the gate current (gate to cathode, with positive voltage on the gate) reaches a critical value. Then the SCR conducts in the forward direction and the gate current no longer has any control — as long as sufficient current flows through the rectifier due to positive voltage on the anode.



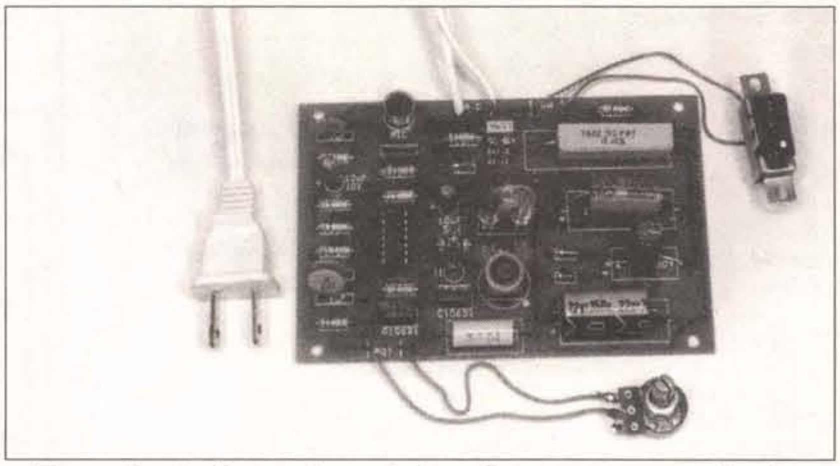
**A complete kit, including the printed circuit board and some hard-to-find parts, is available for $24.90**

As earlier in the discussion of the audio amplifier, when sound is picked up by the microphone and amplified sufficiently, the output of U1-B, through C6 and R5, appears at the gate of Q1. When positive voltage from R2 appears at the anode of Q1 (during the positive half-cycle from the AC line 60 times a second), gate current turns on Q1, and capacitor C3 does some charging during each cycle. This builds voltage at one terminal of the neon bulb I1 and the primary coil of trigger transformer T1.

When the charge on C3 is over about 65 volts, neon bulb I1 fires, caus-



The completed project easily fits inside a VHS video cassette tape box, and can be mounted to the lid.



**Except for the line cord, a switch, and a potentiometer, all other parts are mounted on the printed circuit board.**

ing a positive voltage pulse to reach the gate of SCR Q2. With positive voltage on the anode of Q2 from C3 through the primary of T1, Q2 conducts. This grounds the primary of trigger transformer T1, creating a pulse spike across the primary. Resistor R3 prevents any "misfires" from the highly sensitive SCR gate.

By induction, this voltage spike across the primary of T1 causes a 4,000 volt spike across the secondary winding of T1, triggering the xenon gas tube to conduct, emitting a bright, white flash. This flash continues until C2 is discharged. Once the flash has ended, C2 begins charging again for the next flash.

## Construction

The Party Strobe Light has quite a few parts, many of which are difficult to find. Unless you are good at locating odd parts, or have a very well-equipped junk-box of parts, it is recommended you build the Party Strobe from the complete kit. This includes all the parts and a printed circuit board that is etched, drilled, and silkscreened with the location of all parts.

If you choose to build using some of your own parts, a complete parts list is shown, with some of the hard-to-find parts and the printed circuit board available directly from the kit source. Note that some of the electrolytic capacitors have a high working voltage and are difficult to locate in these days of mostly low-voltage circuits.

Figure 2 shows the single-sided printed circuit board, and Figure 3 is the parts layout. When assembling this project, make sure all polarity-sensitive parts are properly oriented when installed. The polarity-sensitive parts here are the microphone, integrated circuit, electrolytic capacitors, diodes, SCRs, xenon tube, and the trigger transformer.

The microphone should have some indication of the ground lead by looking at the back. The integrated circuit has a notch or indent near pin 1. Electrolytic capacitors normally have the negative lead identified; the other lead is the positive lead. Diodes have a stripe or colored band on the cathode end (the straight line on the circuit symbol).

The specified C106B1 SCR has three leads. Holding the SCR with the metal tab at the top and the beveled edge facing you, the leads at the bottom are, from left to right, cathode, anode, and gate.

For the xenon tube, the black burn on the glass is the cathode, C (pin 3). When mounting the trigger transformer, make sure the terminal identified with a colored dot or stripe is connected to the cathode of the xenon tube.

The resistors, disc capacitors, and neon bulb have no polarity. The potentiometer, looking from the front with the terminals at the top, should have the jumpered wire between the left and center terminals for sound sensitivity to increase when the shaft is turned clockwise.

As always, be very careful that all soldered joints are good (shiny, not grainy) and that there are no solder "bridges" across circuit traces or between pins that are not supposed to be connected.

Also, be certain that all resistors and capacitors are properly placed. Capacitor values are marked with numbers, but small resistors use a color code. If you are not familiar with the color code, see Figure 4. Putting the wrong resistor value in a circuit by misreading the standard color code can wreak havoc with circuit operation.

## Testing

Note that this circuit is powered by 110 VAC, and that some very high voltages are generated. Avoid touching any circuit lead or solder joint, and be sure the soldered side of the circuit board does not come in contact with any metal parts on your workbench!

Before testing the completed circuit, rotate potentiometer R7 fully counter-clockwise, which should be minimum sensitivity. Now, plug the line cord into 110 VAC, turn on the power switch — and nothing should happen! If you see smoke, immediately unplug the power!

Assuming everything seems okay, start talking to the microphone as you rotate the potentiometer shaft slowly clockwise. The xenon tube should start flashing in response to your voice, becoming more sensitive as you rotate the potentiomenter shaft more clockwise. At the maximum sensitivity setting, the xenon tube will flash with a hand clap from over 50 feet away!

## Troubleshooting

The most common reasons for failure of a circuit to work properly are bad soldering and misplaced or misoriented parts, as discussed earlier. Another possible problem could be hairline cracks or shorts on the printed circuit board if you made it yourself. Any part not properly soldered will be slightly loose if you try to move it.

If the xenon tube does not flash, it could have been put in backwards, or its relatively heavy leads might not be soldered properly to the board. Also, xenon tube leads are sometimes covered with a varnish-like substance which should be sanded off before soldering.

If the trigger transformer is misoriented or defective, the xenon will not flash. The DC primary resistance of T1 is about 0.5 ohms, and the secondary about 60 ohms. Also, if SCR Q2 is open or shorted, or U1 is defective, the xenon will not flash.

Suppose the neon I1 flashes, but the xenon does not. Check the voltage across the anode and cathode of the xenon; it should be about 325 volts. If capacitor C2 heats up and pops, either diode D2 is shorted or C2 is installed backwards. For reference, depending on the input AC voltage, here are some typical DC voltage readings you should expect if the strobe is not flashing:

- C1; approximately 165 volts DC
- C2; approximately 325 volts DC
- C3; approximately 60 volts DC
- C4; approximately 165 volts DC
- C5; approximately 10 volts DC

Note that the voltage readings of C1, C2, and C3 should vary up and down if those portions of the circuitry are working properly.

## Packaging

We don't like having circuits with high voltage exposed to curious or misplaced fingers, so we packaged the Party Strobe Light as shown in the photos. The housing is a standard — though translucent — VHS video box.

Four long screws were used through the existing corner holes of the kit-furnished printed circuit board to hold it to the lid of the box.

Before mounting the board, you'll need to drill holes for the screws, as well as a hole above where the microphone will be. You'll also need a slotted hole for the xenon tube to project up through the box lid. Holes will be needed to mount the switch and the potentiometer, and a notch in the side of the box for the line cord.

**RESISTOR COLOR CODE**

SEE (*) BELOW

| BAND COLOR | 1st DIGIT | 2nd DIGIT | MULTIPLIER |
|---|---|---|---|
| BLACK | 0 | 0 | 1 |
| BROWN | 1 | 1 | 10 |
| RED | 2 | 2 | 100 |
| ORANGE | 3 | 3 | 1,000 (K) |
| YELLOW | 4 | 4 | 10,000 |
| GREEN | 5 | 5 | 100,000 |
| BLUE | 6 | 6 | 1,000,000 (M) |
| VIOLET | 7 | 7 | 10,000,000 |
| GRAY | 8 | 8 | 100,000,000 |
| WHITE | 9 | 9 | 1,000,000,000 |

*TOLERANCE: NO COLOR 20%; SILVER 10%; GOLD 5%

**Figure 4: Resistor Color Codes**

## Using the Party Strobe Light

The intended use for the Party Strobe Light is to react to a musical or drum beat. Turn it on in the sound environment, set the sensitivity to minimum, and then increase the sensitivity until the strobe picks up the beat.

Of course, if there is a lot of background noise, the Party Strobe will "hear" that as well, so set the sensitivity for the optimum lighting effect. Add a rotating mirrored ball and you can have a simple home disco of your own.

You can also use the Party Strobe as a sensing device to flash whenever a desired sound is heard. For example, placed near a ringing telephone, with the sensitivity set low enough to ignore ambient noise, the Party Strobe will flash when the phone is ringing — a real need for the those with limited hearing.

Also, it can detect an attempted burglary when placed near a door or window so that it will flash if the door or window is rattled with attempted entry. Knowing that they have been detected will discourage all but the most determined burglars!

You may discover other uses for this versatile device. **NV**

# IOKit and Bridge Software

by Don L. Powrie

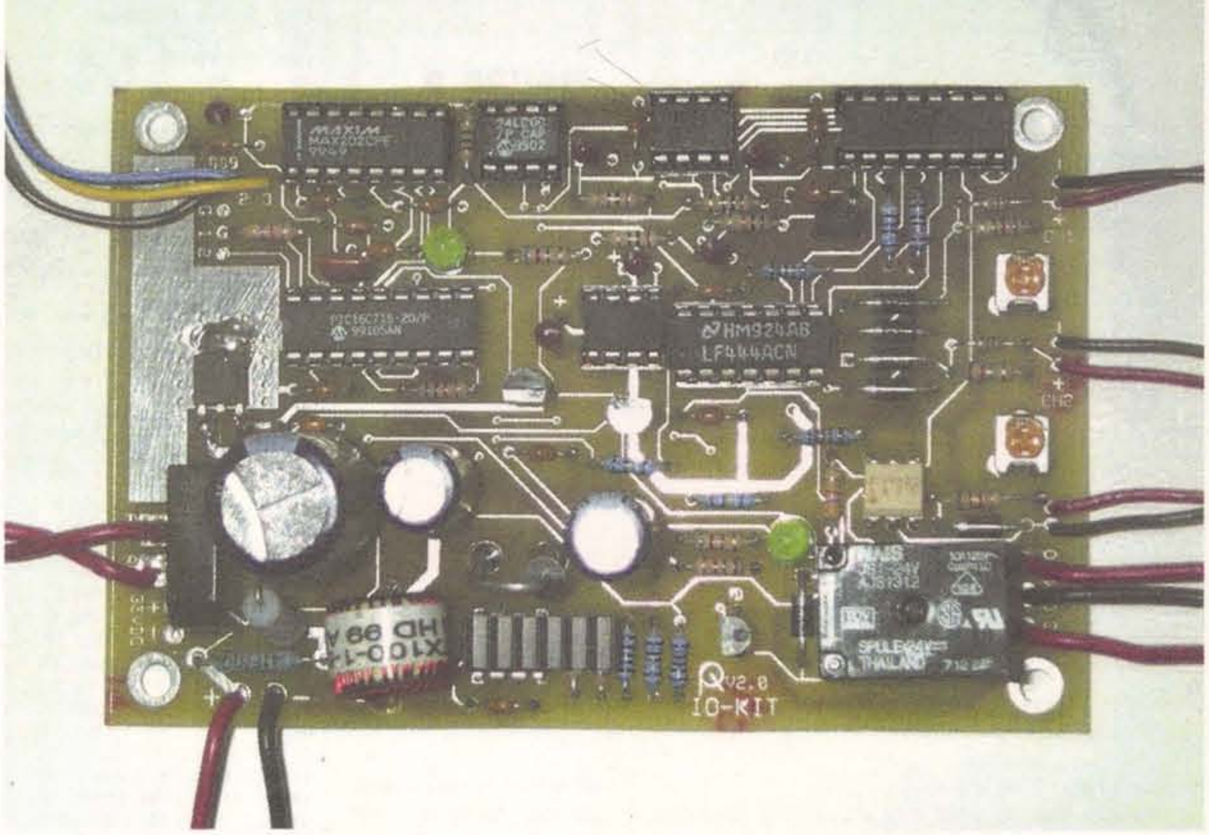
Sit down at just about any technician's workbench, and you will find a power supply of some sort. I bought mine from RadioShack when I was about 10 years old. It has an on-off switch, a knob to select the voltage, an analog meter to display the voltage and current, and a switch to select what the meter measures; either voltage or current. I doubt that I can count the number of times I've tried to adjust the output for an exact 5.0 volts using the analog meter. In retrospect, I probably never hit 5.0 volts exactly due to the inaccuracy of the analog meter.

Over the years, I've come close to retiring the old power supply in favor of a newer one with digital readouts and multiple outputs, but I didn't because the new supply wouldn't give enough of an advantage over what I already had ... especially considering the cost.

I finally decided that in order to justify the expense, the new supply had to provide a significant increase in capability over what I already had. This meant computer control and programmability. The few power supplies I've seen on the market that have a PC interface (serial port, GPIB/HPIB) are a little out of my comfort zone price wise.

When I embarked on this project, I decided that the goal for the end product would be a supply with specs similar to those of my old RadioShack unit. The output would go from 0-20 volts with a maximum output current of just over one amp. In addition, the supply would be able to accurately measure its own output voltage and current and report it back to the host PC. Then, since I was going to this much trouble, I decided to add several other features like a two-channel voltmeter, an SPDT relay, an optically isolated digital input and some expandability. (We'll cover these features later in detail.)

**PCB — Fully Assembled**



## Switching Regulator

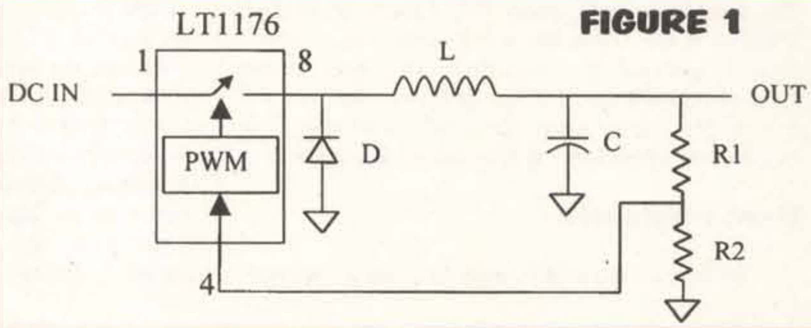
For this power supply, I decided to use a switching regulator (LT1176) and avoid the large heatsinks that are normally found on the medium-to-high power linear voltage regulators. The power that must be dissipated by a linear regulator and heatsink can be calculated by subtracting the regulator's output voltage from its input voltage and multiplying that voltage drop by the current into the load.

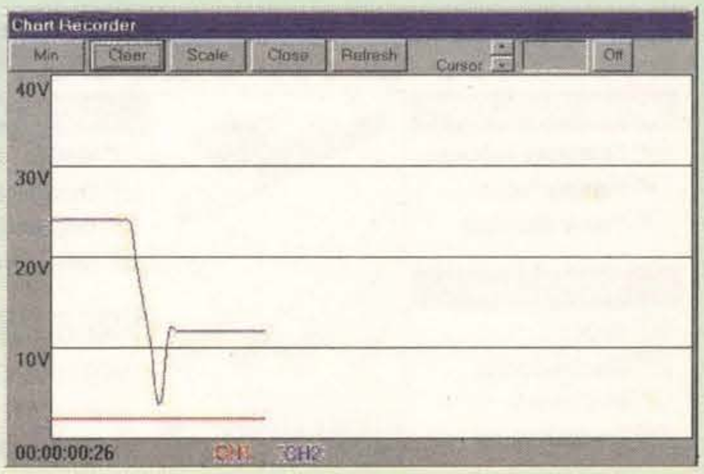
For low output voltages, this dissipated (or wasted) power can be rather high. For instance, if the voltage into the regulator is 22 volts, the output is two volts and the load is drawing one amp of current, then the total power dissipated in the regulator is 22V - 2V / 1A or 20 watts of power lost in the form of heat in the regulator.

A switching regulator controls its output voltage by varying the duty cycle of a squarewave that is used to open and close a transistor switch. When the switch is open, no energy is used by the regulator or load. When the switch is closed, a very small amount of energy is lost in the switch itself, and the vast majority is passed through to charge the external capacitor. The regulator itself dissipates much less energy and, as a result, is much more efficient than a linear regulator. The efficiency of both regulators can be calculated with power out / power in x 100%. (It is worthy to note that the efficiency of linear regulators can be as low as 10%, while switching regulators are typically 70% efficient or higher!)

For this power supply design, the duty cycle of the main power switch located in the LT1176 (U8) is varied until the desired voltage is reached at the summing node connected to pin 4 (Figure 1). When the switch closes, current flows through the inductor (L) creating a magnetic field of energy stored in the form of magnetic flux. This current also charges capacitor (C). When the switch opens, the magnetic flux will collapse with an opposite polarity. Diode (D) then becomes forward biased, and passes the collapsing energy from the inductor to ground. The charge on the capacitor appears at the output and is also divided down by resistors (R1) and (R2), which serve as feedback to the Pulse Width

**FIGURE 1**




**Bridge101.EXE's chart recorder dialog**

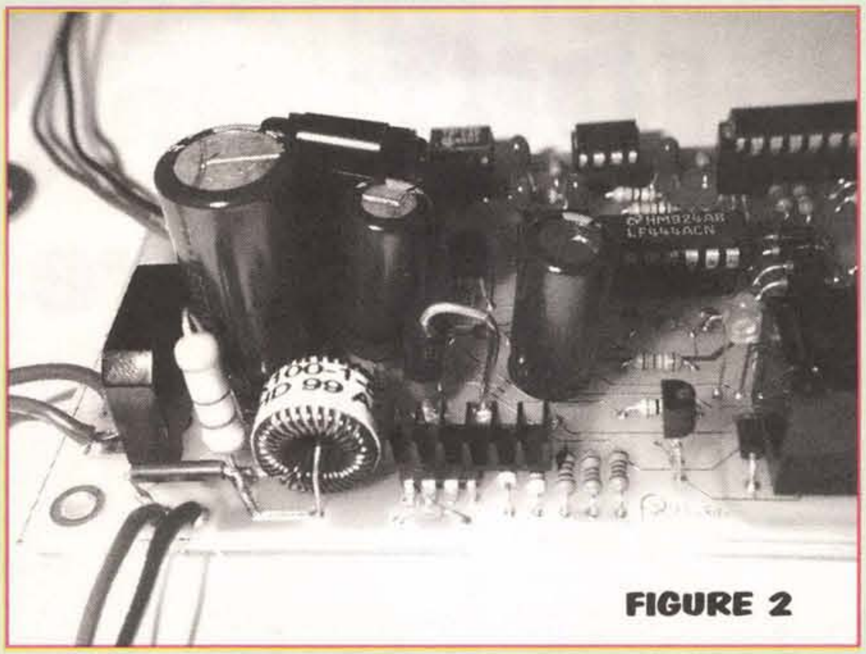
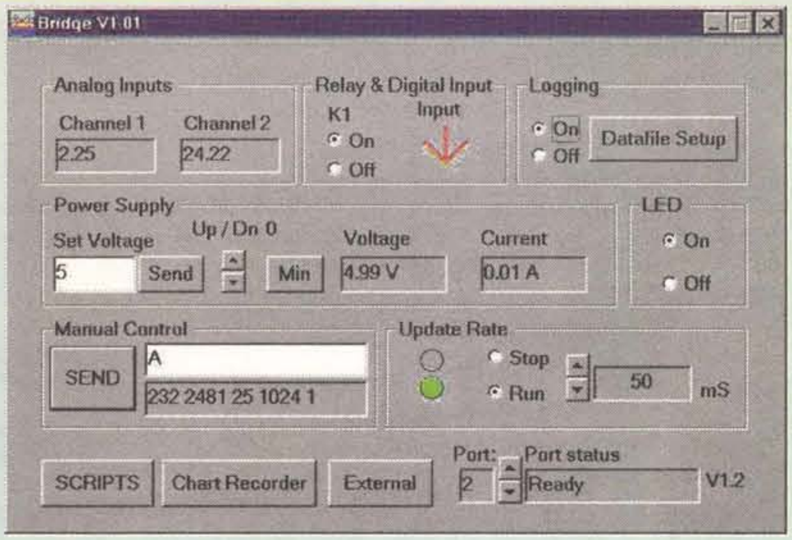


FIGURE 2




**Bridge101.EXE main program window**

Modulator to close the loop.

By now you are probably wondering, why do I need the inductor and diode? Why can't there just be the switch and capacitor? The inductor limits the inrush current when the switch is closed. Without it the capacitor would look like a direct short to ground. In reality, there are losses in this type of regulator, and it can get quite hot, but the losses are much lower than non-switching type regulators, especially at low output voltages.

### Heat Dissipation

While you wouldn't expect to see a heatsink attached to an eight-pin dip package, I am including one in the IOKit listed at the end of this document. It is very small (Figure 2) and can be attached with a single drop of Super Glue® or any thermally-conductive adhesive. There are other tricks that can help pull the heat away from the

| | | Part # | Reference Designator | |
|---|---|---|---|---|
| 1 | 16MHz resonator | X908-ND | CR1 | 1 |
| 2 | Microcontroller | PIC16C715-20/P | U6 | 1 |
| 3 | Neg 5V Inverter | ILC7662 PDIP | U9 | 1 |
| 4 | A/D | ADS7841P | U4 | 1 |
| 5 | DAC | DAC7611P | U7 | 1 |
| 6 | SW Regulator | LT1176CN8 | U8 | 1 |
| 7 | EEPROM | 24LC00/P | U11 | 1 |
| 8 | op amp | LF444ACN | U3 | 1 |
| 9 | optoisolator | 4N25 | U10 | 1 |
| 10 | 12V Regulator | MC78M12CDT | U2 | 1 |
| 11 | 5V Regulator | NJM78L05A | U1 | 1 |
| 12 | 24V Regulator | NJM78L24A | U12 | 1 |
| 13 | RS232 chip | MAX202CPE | U5 | 1 |
| 14 | Inductor | Coiltronics CTX100-1-52 or Pulse Engineering PE-92102 | L1 | 1 |
| 15 | transistor | 2N3904 | Q1 | 1 |
| 16 | diode | 1N4001 | D3,4,5, 6,8,9 | 6 |
| 17 | Schotty Diode | 1N5822 | D7 | 1 |
| 18 | bridge 4A | RS403LMS-ND | BR1 | 1 |
| 19 | LED - Green 12V | 160-1130-ND | D1,11 | 2 |
| 20 | 5V Reference | LM4040AIZ-5.0 | D2 | 1 |
| 21 | DB-9 Conn | A2043-ND | P1 | 1 |
| 22 | Power Transformer | Hammond 166L24 (HM547-ND) or Magnetek VPS24-1800 MCI Transformer 4-47-5-024 (dual pri) | T1 International Use | 1 |
| 23 | relay | 24V, 13mA coil, SPDT | K1 | 1 |
| 24 | socket 8 pin | | | 3 |
| 25 | socket 16 pin | | | 2 |
| 26 | socket 18 pin | | | 1 |
| 27 | socket 14 pin | | | 1 |
| 28 | CAP 2200/50 | P5187-ND | C1 | 1 |
| 29 | CAP Tant 10/10 | P2026-ND | C4,5,7, 12,14, 25 | 6 |
| 30 | CAP CER .1/50 | 1210PHCT-ND | C2,3,6, 8,9 | 13 |
| 31 | >>>>>>>>>>> | >>>>>>>>>>>>>>> | C10,11,13,15, 16,22,23,24 | |
| 32 | CAP ELE 470/50 | P5185-ND | C18,19 | 2 |
| 33 | CAP CER .01/50 | 1206PHCT-ND | C17 | 1 |
| 34 | .1Ohm/2W resistor | 12FR100-ND | R19 | 1 |
| 35 | RES 1.87K 1/4W 1% | 1.87KXBK-ND | R13 | 1 |
| 36 | RES 3.16K 1/4W 1% | 3.16KXBK-ND | R12 | 1 |
| 37 | RES 10.0K 1/4W 1% | 10.0KXBK-ND | R14 | 1 |
| 38 | RES 113K 1/4W 1% | 113KXBK-ND | R20,22 | 2 |
| 39 | RES 2.94K 1/4W 1% | 2.94KXBK-ND | R18,21 | 2 |
| 40 | RES 9.76K 1/4W 1% | 9.76KXBK-ND | R25 | 1 |
| 41 | RES 2.87K 1/4W 1% | 2.87KXBK-ND | R26 | 1 |
| 42 | RES 10K 1/4W 5% | 10KQBK-ND | R2,5,15,30 | 4 |
| 43 | RES 47K 1/4W 5% | 47KQBK-ND | R3, 31 | 2 |
| 44 | RES 1K 1/4W 5% | 1KQBK-ND | R4 | 1 |
| 45 | RES 2.7K 1/4W 5% | 2.7KQBK-ND | R16 | 1 |
| 46 | RES 620 1/4W 5% | 620QBK-ND | R34,35 | 2 |
| 47 | POT 500K single turn | D4AA55-ND | R23,24 | 2 |
| 48 | RES 10M 1/8W 5% | 10MEBK-ND | R6,8 | 2 |
| 49 | RES 1.2M 1/4W 5% | 1.2MQBK-ND | R7,9 | 2 |
| 50 | RES 10 1/4W 5% | 10QBK-ND | R27,28, 32 | 3 |
| 51 | RES 120 1/4W 5% | 120QBK-ND | R33 | 1 |
| 52 | RES 430 2W 5% | 430W-2-ND | R17 | 1 |
| 53 | Heatsink | HS227-ND | IC HEATSINK | 1 |

Note: The following items are available from Protoqual. Click on **www.protoqual.com** for details. Orders only **1-888-291-2111**. Double-sided, printed-circuit board with plated-through holes, $19.95; Preprogrammed U6, $19.95; Complete kit of all electrical components, PCB, microprocessor and power transformer, $149.95. Shipping and handling extra. CA residents must add appropriate sales tax.

LT1176. Pins 1 and 8 are the input and output for the main switch, and will have the most heat of any of the pins. The printed circuit board used should have as large a foil pattern connected to pins 1 and 8 as is practical to help draw some of the heat away from the package. Additionally, do not use a socket for U8.

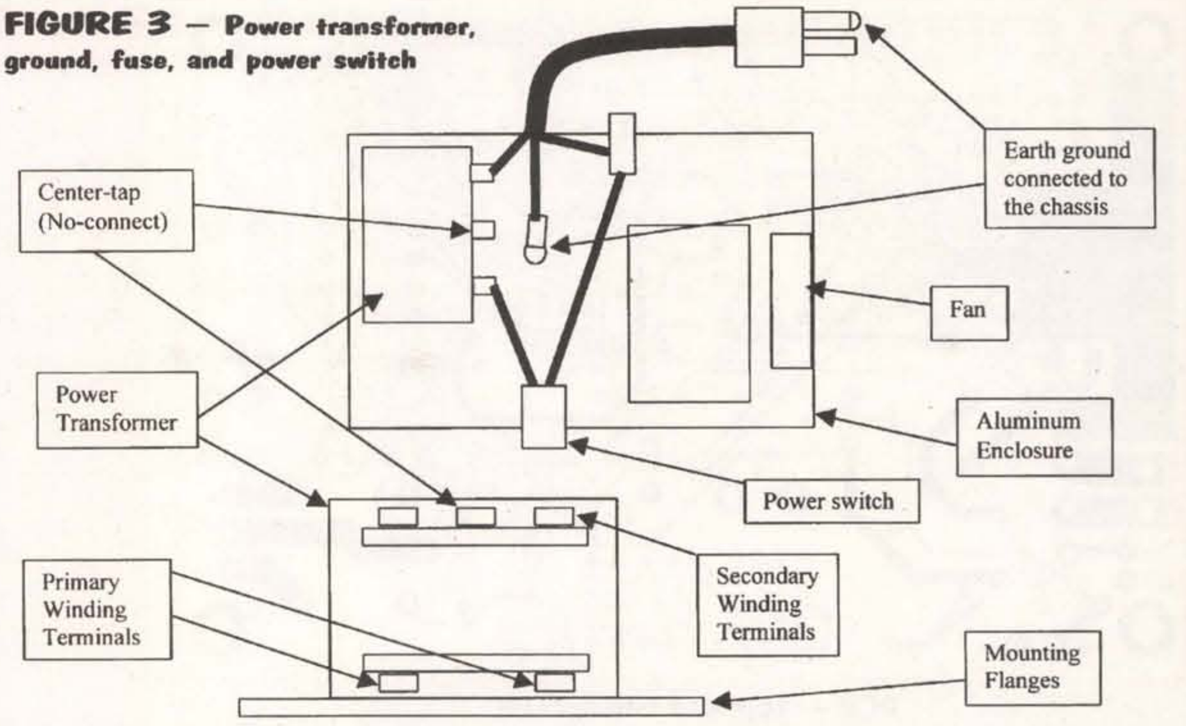
The last step is to add a fan blowing directly on U8 and the PCB. While these heat-sinking measures are not mandatory, they can help keep the output voltage from sagging in situations where one amp of current is required.

## DAC Control

To drive the regulator, I used a Burr Brown DAC7611 digital-to-analog converter. This DAC is a voltage output type, and generates from zero to 4.096 volts. This voltage is then buffered through a unity gain op amp that drives the summing node of the LT1176.

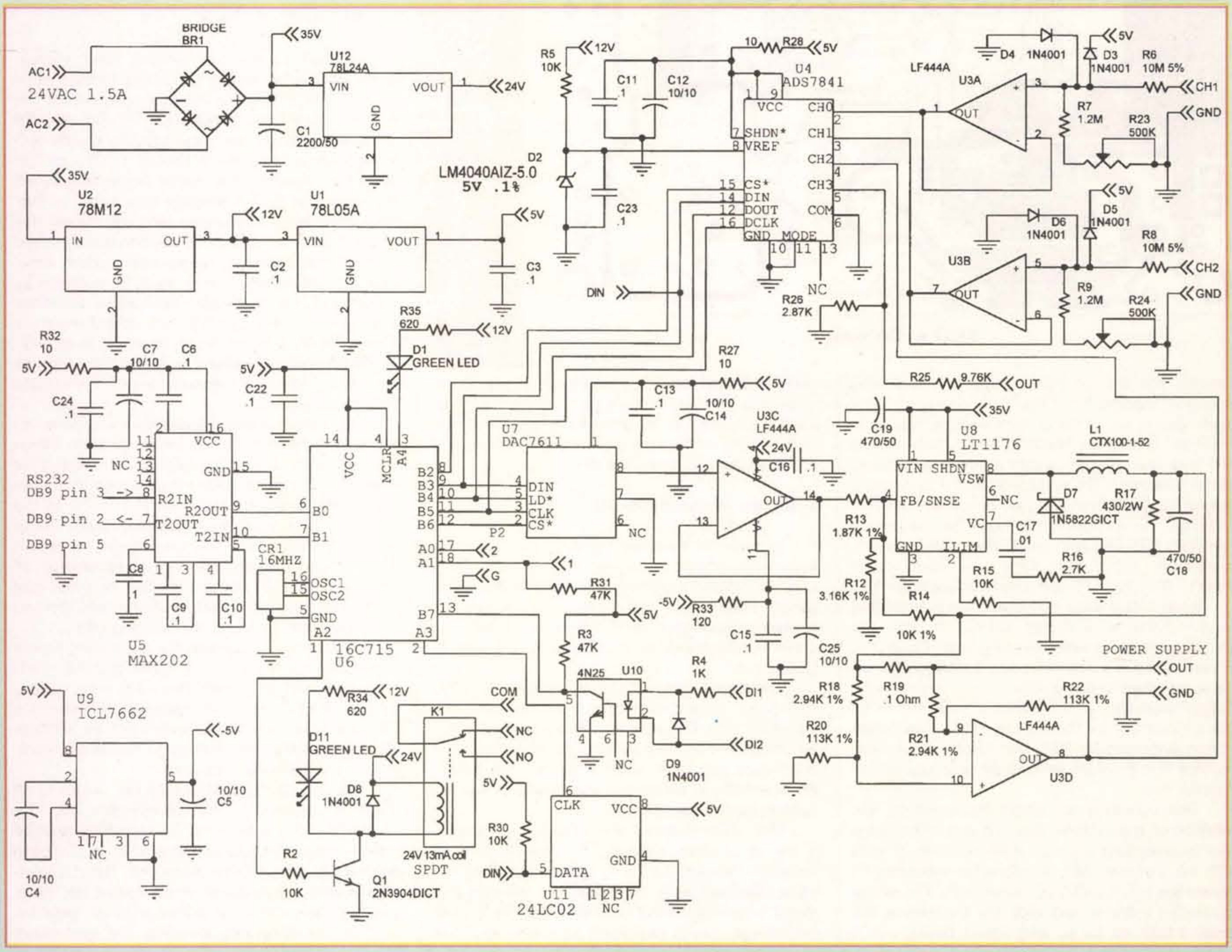
The voltage from the DAC has an inverse relationship to the output of the regulator. As the DAC output voltage goes up, the output of the regulator goes down. Pin 4 of the LT1176 is the feedback pin or summing node. The output of the regulator will do whatever it must to maintain 2.21V at pin 4 of the LT1176. To this end, the values of R12, R13, and R14 were specifically chosen so that when the DAC output is at zero volts, the regulator is at its maximum output (about 21 volts); and when the DAC output is at 4.096 volts, the regulator output is at zero volts.

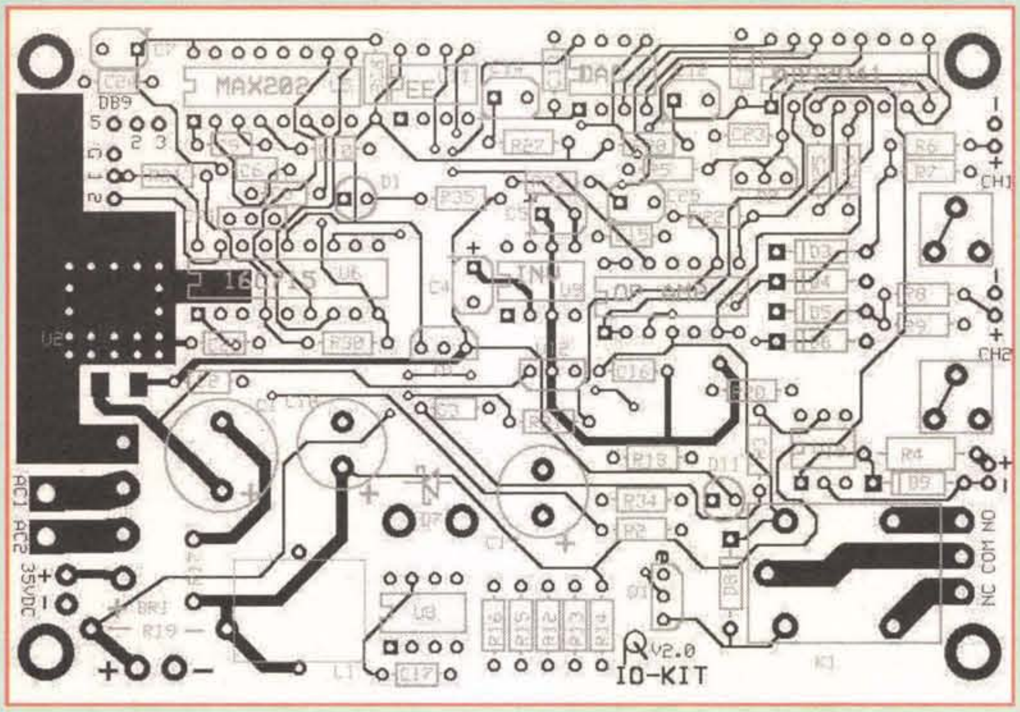
**FIGURE 3 — Power transformer, ground, fuse, and power switch**



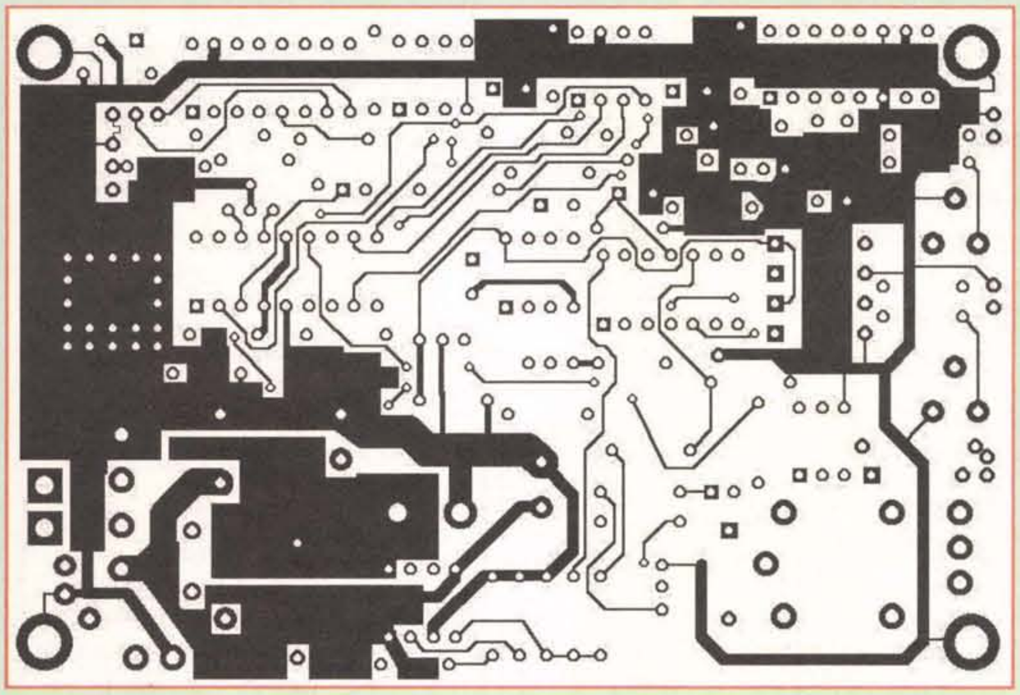

## Program Control

The DAC is controlled by the 16C715 microcontroller, but since there is no direct correlation between DAC output voltage and regulator output voltage, the power supply cannot be directly set to an exact voltage. Instead, the microcontroller must work with the DAC and A/D converter to search for the desired voltage. This is accomplished by moving the DAC in small steps






**PCB — Top and Silkscreen**



**PCB — Bottom**

towards the desired power supply voltage and taking a reading from the A/D converter after each step to see if the desired voltage has been reached. Thankfully, the DAC and A/D converter are very fast, so the overall process only takes about a second. The resolution of the regulator's output is about 5mV, so just about any voltage between .1 and 20 volts can be achieved. Resistors R25 and R26 divide the power supply's maximum output down to a maximum of five volts so that the A/D converter can measure it.

While this design works well when searching from a lower to a higher voltage, it does not always perform as well searching from a higher to a lower voltage when there is a light load (or no load) attached to the output. This is because the output capacitor (C18) wants to hold on to its charge and not let the voltage drop. This condition is improved by R17, the 430-ohm, two-watt resistor that provides an ever-present load to the supply.

This condition is further improved by the addition of any external load. (It should be noted that in searching from 20 volts down to .5 volts with no external load, it might be necessary to repeat the SET VOLTAGE command.) The microcontroller software will only try to achieve the desired setpoint for so long before timing out. If given sufficient load, the search routine performs quite well, and any voltage from about 100 millivolts to 20 volts can be achieved in about one second, as long as the load does not draw more than the regulator's current limit of one amp.

## Current Measurement

In order to measure the amount of current being drawn from the power supply, a very low-ohmage resistor is placed in series with the power supply output, and the voltage drop across the resistor is measured by the A/D converter. The current can then be calculated using simple Ohm's Law.

The circuit uses a 100-milliohm resistor (R19) and an op amp configured as a difference amp with R18, R20, R21, and R22 to measure the voltage drop. The op amp selected for this circuit is a little more expensive than most, but the added expense will pay for itself in this and two other circuits to be discussed later.

One of the features of the LF444A op amp is a low input offset voltage. The manufacturer — National Semiconductor — guarantees that the input offset will be no more than five millivolts and that it is typically about two millivolts. The low offset voltage spec is important because the circuit must multiply the voltage dropped across R19 by 38.4 (113K / 2.94K ohms) to fully use the 0-5 volt input voltage range of the A/D converter. Any offset error present at the input of the op amp will be multiplied right along with the voltage we are trying to measure. While the LF444A op amp works well for this circuit, I should mention that there are other op amps available with much lower input offset voltage specs. Of course, as the spec for the offset voltage goes down, the price for the part goes up ... way up!

To calculate the gain needed by the difference amp, I began with the assumption that the maximum amount of current that will ever be drawn from the switching regulator is 1.3 amps. This is acceptable since the LT1176 is limited to a maximum current of just over one amp by R15. The voltage dropped across a .1-ohm resistor with 1.3 amps running through it is 130 millivolts (.1 ohms x 1.3 amps), so the difference amp needs a voltage gain of 38.4615 to fully utilize the 0-5 volt range of the A/D converter. R18, R20, R21, and R22 were selected for a gain of 38.43 which is pretty darn close. These resistor values only come in 1% tolerances unless you want to take an ohmmeter and hand-select your parts.

## A/D and Analog Inputs

Both analog input channels have an input range of from 0-40 volts with 10-millivolt resolution. A 12-bit A/D can resolve 4,096 ($2^{12}$) steps between zero and five volts.

40 / 4096 = 9.76 mV

In order to have an analog input voltage range of 0-40 volts, the incoming voltage must first be divided down to the 0-5V range which the A/D converter can handle. R6, R7, R8, and R9 divide the voltage down and provide a sufficiently high input impedance (about 11 Mohms) to keep from loading the circuit being measured. However, the A/D converter has about a five-megaohm input impedance, and the overall system accuracy would most likely be compromised by the resistor divider. To maintain system accuracy, the incoming voltage must be buffered by an op amp. This is another area where the more expensive op amps justify their added expense. The LF444A has an input impedance of $10^{12}$ ohms (tera-ohms), which is sufficiently high to keep from affecting the accuracy of the resistor voltage divider.

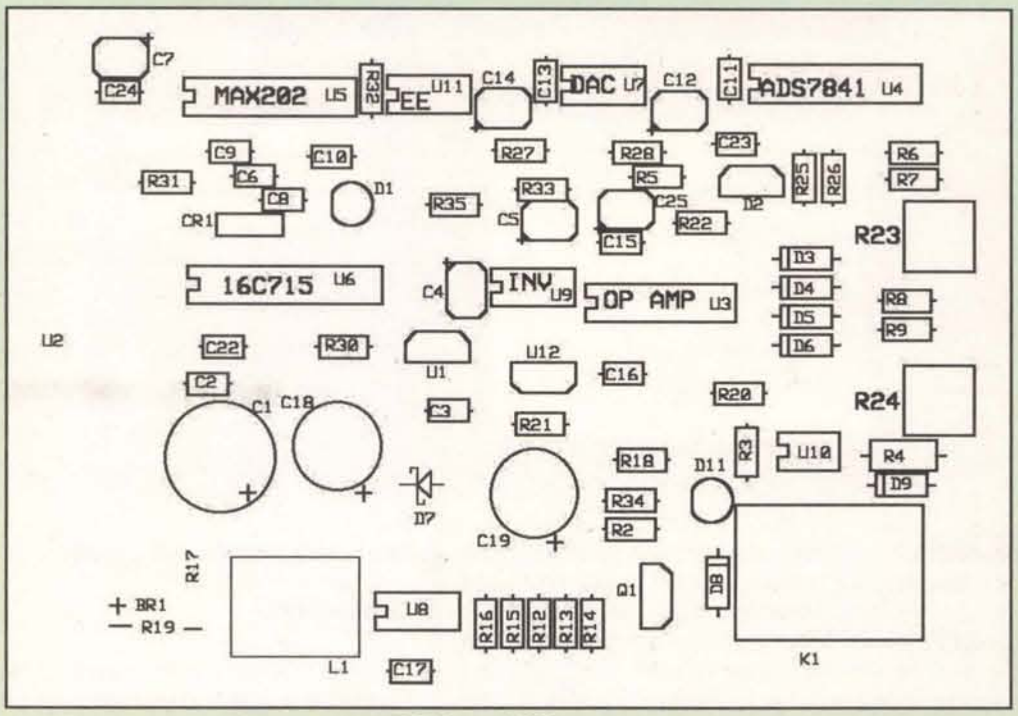
The circuit being measured must have an output impedance of 10K ohms or less, otherwise an error due to loading could result. This error happens because the impedance of the circuit being measured is added in parallel to the input impedance of the measuring device. Keep in mind that any time you are trying to measure the voltage dropped across a resistance of greater than 10K ohms with this or most any other voltmeter, you will probably not get an accurate reading due to this loading effect.

Overvoltage protection for the analog inputs is provided by diodes D3, D4, D5, and D6 which pass any voltage greater than 5.6 volts or less than -.6 volts to the power supply. Potentiometers R23 and R24 provide calibration for the voltage dividers to keep from having to locate the hard-to-find 1%, 10M-ohm resistors.

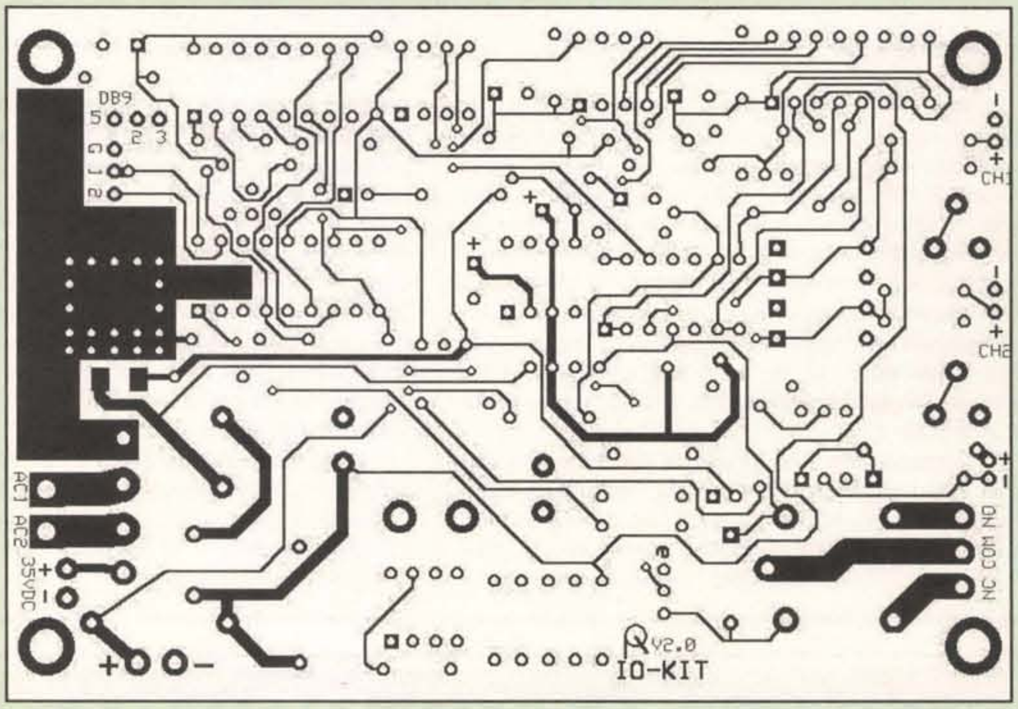
The last device that affects the accuracy of the A/D converter is voltage reference D2. The LM4040AIM3 is a five-volt, .1% precision voltage reference that the A/D converter uses to compare against the voltage to be measured. The .1% tolerance makes this device more expensive, but this is another case where the added expense pays for itself in overall system accuracy. The spec sheet

for this device states that a bypass cap isn't necessary, but I found that the A/D converter ran a little quieter (one LSB) with the .1 uF cap.

The overall accuracy of the analog inputs is affected by the source impedance of the circuit being measured, the input offset of the op amp, the noise in the A/D converter's power supply, the A/D converter itself, and the precision voltage reference. In my tests, I found the total system error to be less than 1%, and that was mostly due to system noise.




**PCB — Silkscreen**




**PCB — Top**

## Power Source for the Power Supply

The power transformer selected for this system must satisfy several criteria. It must (1) provide sufficient current for the switching voltage regulator; (2) have a high enough output voltage so that the 24-volt regulator doesn't drop out under heavy power supply loads or low line voltage; and (3) not have so high an output voltage that it overdrives either of the linear voltage regulators. A 24-volt, 1.5-amp transformer will work best in this application. The voltages needed for this design are +5V, -5V, +12V, and +24V.

Standard linear voltage regulators work well for all of these voltages except the -5V. The ICL7662 was used for generating the -5V since the only external components it requires are two tantalum capacitors. It only provides about 10mA without starting to sag, but that should be sufficient since the -5V is only needed for the op amp's negative rail. This is another area where a more expensive op amp justifies its cost. The LF444A only requires 200 microamps per amplifier, as compared to some op amps that require five milliamps or more per amplifier. This 800 microamps combined with the op amp's output current is less than five milliamps, so the ICL7662 works just fine.

## Noise in the Power Supply

Controlling power supply noise in any circuit can be a challenge. If you are trying to minimize the LSB dither (noise) of an A/D converter, then power supply noise can be your worst nightmare. A/D converters need a very quiet power source. If you can't get the noise down to an acceptable level, the converter's LSBs will dance with wild abandon.

Bypass caps and other noise reduction techniques can be used to both attenuate noise on the power bus that could affect the performance of an integrated circuit and keep noise that is generated by an integrated circuit from getting on the bus. Some devices can get by with just a .1uF bypass cap, while others need a little more isolation from the power bus. The A/D and DAC both need more isolation from bus noise, while the serial interface chip needs to be isolated from the bus so that the noise it generates in the process of creating ± 10 volts from +5 volts doesn't get onto the bus. For this circuit, adding a 10-ohm resistor in series with the +5-volt bus just before the bypass caps is sufficient for reducing noise to an acceptable level.

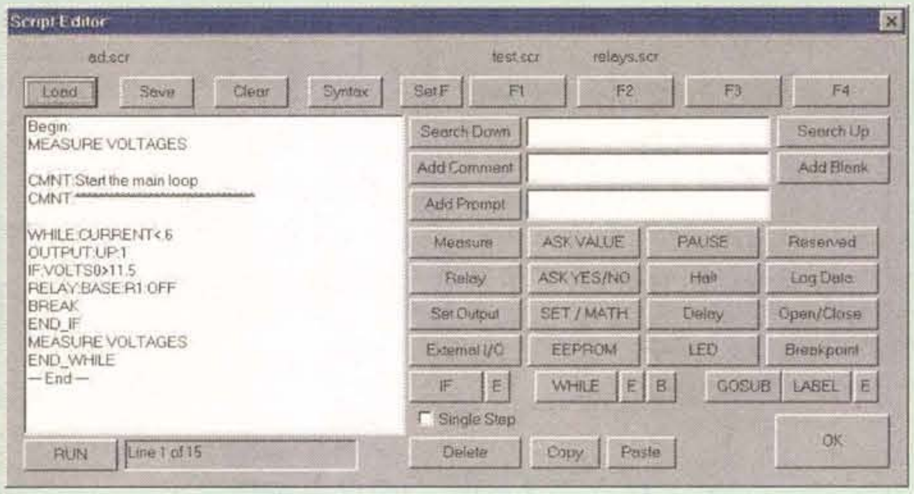
## SPDT Relay, OPTOISOLATOR, LED, and EEPROM

Since there were leftover port pins on the microcontroller after the switching regulator design was complete, I added a few gadgets that I thought might come in handy. The relay is of the single-pole/double-throw persuasion, and is driven by a simple NPN transistor. Make sure to select a relay that draws less than 50mA from the 24-volt regulator.

The digital input uses an optoisolator that pulls its output low when sufficient current is applied to the input to make its internal emitter diode start to conduct. The optoisolator will report a "high" input condition with any positive input voltage above two volts. The 1K resistor (R4), which limits the current through the emitter diode, is a 1/4-watt device which sets the upper limit on the applied voltage to about 12 volts assuming 50% power derating on the wattage of the resistor and continuous operation.

There are two LEDs in this design: one that goes on and off with the closing and opening of the relay; and the other which is connected to the open drain output (port pin A4) of the microcontroller. The LED connected to the microcontroller is turned on about 500 milliseconds after power up and can be turned on and off via software.

The EEPROM is a 2K bit device configured as 256 eight-bit bytes. This non-volatile device can be used to store setup parameters, program/script




constants, or anything else that can be stored eight bits at a time. Of course, integers larger than eight bits and floating point numbers can be stored in the EEPROM by breaking them down into eight-bit pieces first. Remember to wait for 10mS between successive writes to the EEPROM. The spec for the write speed varies from manufacturer to manufacturer but waiting 10mS between writes generally works well.

## External I/O

With the remaining two microcontroller port pins, I decided to implement a port that could communicate with external devices. I labeled the ports 1 and 2, but they are really transmit and receive lines. I decided on 1 and 2 so that external boards labeled in the same way could be easily connected without the ambiguity of having to determine whether to connect transmit to receive or transmit to transmit. A complete description of the communications protocol is included with the IOKit and is also available from my website (www.protoqual.com).

Currently, the only products available that use this external I/O port are a relay board with eight individually controllable relays and an eight-channel, optically-isolated digital input board (not CMOS or TTL compatible). Information on both kits is also available on my website.

## Software

The serial protocol implemented in the microcontroller is rather unsophisticated in that it doesn't require checksums and doesn't have a long list of error codes that can be returned to the host PC if something goes wrong. In fact, if the microcontroller receives a command that it doesn't understand, it simply responds with "WHAT?"

Two software programs are available for downloading for free from the website as well. The first is BRDG_DOS.EXE, which is a DOS based program that will issue commands to the microcontroller at a fixed baud rate of 19,200 baud and print the microcontroller's raw data response to the screen. This program is intended to be a development tool for those wishing to write their own Windows/DOS software for communicating with the microcontroller. The second program (Bridge101.EXE) is a full implementation of all features and functions of IOKit, and will run under Windows 95, 98, or NT.

Its features include a chart recorder window for graphically monitoring the voltages of both analog channels 1 and 2, the ability to set the voltage and monitor the current of the switching voltage regulator, and a point-and-click interface for control of the relay and LED indicator. Last, but certainly not least, Bridge101.EXE has a fully functional scripting language interpreter. With it, you can build long lists of commands using WHILE loops and IF statements that let you set up a mini automated test system in your home workshop.

## Construction

**NOTE: Do not attempt to connect the power transformer to 120VAC unless you are experienced with both high voltage and the wiring of high-voltage components.** Make sure your work area is free of static electricity. Some of the integrated circuits in this design can be easily weakened or damaged by a static discharge that is too small to be felt by your hand.

Start by placing all of the resistors, capacitors, ICL7662, and 78xxx series linear regulators on the board first. Apply power to the board, and verify that all of the voltage regulators are issuing the correct voltage. Then remove power from the board and install the 16MHz ceramic resonator, MAX202, and microcontroller chips. Connect the board to the host PC via the three-wire interface, and then apply power. Test for correct communication by running BRDG_DOS.EXE with the following command: BRDG_DOS 1 P where "1" is the serial port number that the IOKit is connected to and "P" is the command for "Ping." The IOKit should return with "IOKit V1.xx. If it does not, check all solder connections, and verify that all resistors are the correct value and in their correct location on the board. Once the microcontroller is running, place the rest of the components on the board, re-apply power, and you're ready to roll.

## Additional Parts

Mounting the IOKit PCB within an enclosure will require additional parts (ref. Figure 3). The enclosure selected should be made of aluminum or some other metal so that it can be electrically connected to earth ground (usually the green wire in a three-conductor power cord). The enclosure should have a fan mounted adjacent to the circuit board so that air will flow across the switching regulator circuitry. Standoffs will be needed to mount the PCB so that it doesn't short out against the enclosure. Mount the power transformer in a corner for better structural support with its power connections pointing towards the middle of the enclosure.

Miscellaneous wiring terminals can be mounted to the enclosure and connected to the PCB. Make certain that you add a power switch and a fuse in series with the power cord and primary winding of the power transformer. A 500mA, 250-volt fuse will work just fine.

The only calibration that can be performed is to set the voltage divider potentiometers R23 and R24. Apply voltage to analog input channel 1 and monitor the voltage at the PCB terminals with a digital voltmeter. If available, use 39 volts DC for the calibration voltage. If not, use as high a voltage as you can get (less than 40 volts). Adjust R23 for the correct voltage reported by Bridge101.EXE and repeat this procedure for channel 2. **NV**

# New Product News

### SURETESTER L™

The SureTester L™ is a hand-held battery-powered test instrument. It is easily carried and can be connected to a powered down motor in seconds. The motor's condition is determined by flipping a switch and reading the resulting delta number on the backlit display. A chart on the front of the tester equates the delta number to the motor's status. Within seconds you will know the condition of the motor.

No more guessing with a megaohmmeter. You can even test through your starter and wiring.

The SureTester L will test: single or three-phase AC motors and AC servos fractional to 250 HP, 50 or 60 Hz, and 100 to 500VAC.

The SureTester L comes complete with: batteries, case, test leads, and two-year limited warranty.

For more information, contact:

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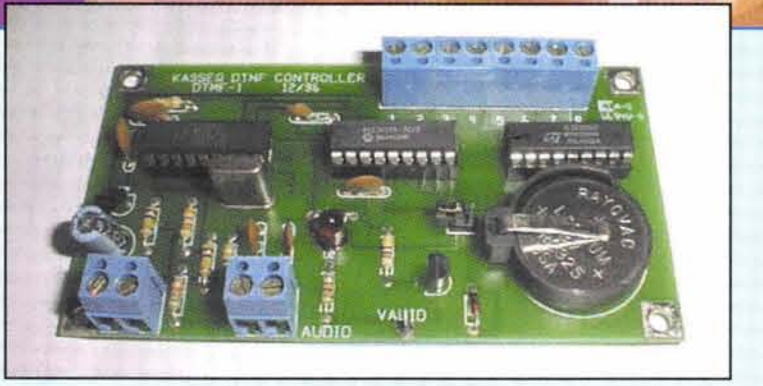

### EIGHT-CHANNEL DTMF (TOUCH-TONE) CONTROL BOARD

Uddle Systems presents the DTMF-1. This board listens to any audio source such as telephone line, two-way radio, scanner or satellite receiver. Each of the eight outputs can be programmed for latched (on/off) or momentary (0.25-32 second pulse) operation.

Each output provides up to 500 mA of current sink. The DTMF-1 will drive relays directly for control of high current loads.

Ideal for commercial and amateur repeater control, dial-up telephone control (requires an answering machine), and call screening.

The DTMF-1 features two-level command security, programmable one-to-five digit user, and programming passwords, individual channel lockouts, programmable command acknowledge channel, valid tone LED, and mute output. Other features include: on-board lithium battery retains programming in the event of a power failure; easy connection to any system via mini screw terminal connections; and requires 6-30 volts DC.

See the website for more information and application hints. The cost is $59.95 plus $5.00 shipping by Priority Mail. Visa/MC/Discover accepted.

For more information, contact:

**UDDLE SYSTEMS**
**825 SHERMAN AVE., DEPT. NV**
**ACKLEY, IA 50601**
**VOICE/FAX: 1-877-733-4351**
**WEB: http://www.uddle.com**

### THE PEDALER™

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The new and unique Pedaler exercise system will get you moving and help keep you healthy as we move into the 21st century!

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### INTERNET-BASED TEMPERATURE/RELATIVE HUMIDITY DATALOGGER

Pinnacle Technology, Inc., introduces the ezLogger/TRH, the first Internet-based temperature and relative humidity datalogger. The ezLogger/TRH offers worldwide access from any computer with an Internet connection and the proper password.

The ezLogger/TRH provides real-time monitoring of environmental conditions, and web-based downloading of collected data, ending the need for labor intensive manual downloading.

Room conditions are monitored at 2-30 minute intervals. Easy to read text and graphic displays show daily or long-term trends in room conditions.

Previously logged data can be downloaded in spreadsheet compatible format via email or directly from any web browser.

Temperature and humidity alarm limits, email alarm destinations, sampling rate, unit identfication, and network settings can be easily changed through a telnet or serial connection.

The ezLogger/TRH is compatible with any web browser. No additional software is required.

Immediate alarms will be emailed whenever temperature or relative humidity limits are exceeded or standing water is detected (optional water sensor).

The ezLogger was designed specifically for library and museum conservation professions, but is also applicable for computer rooms, warehouses, hospitals, and industrial applications, wherever accurate, reliable monitoring of temperature and humidity is required.

For more information, contact:

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**DEPT. NV**
**LAWRENCE, KS 66044**
**785-832-8866 FAX: 785-749-9214**
**EMAIL: info@pinnaclet.com**
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# APPMOD SQUAD

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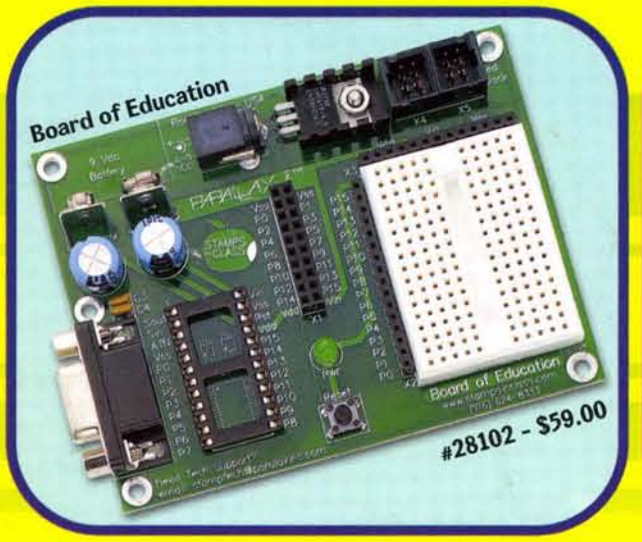



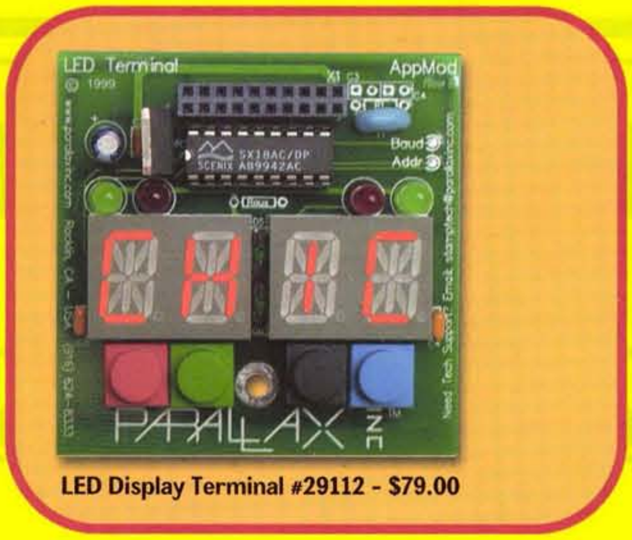



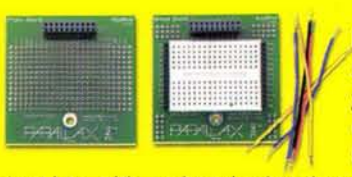

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For example, sound may be recorded using serial commands or the pushbuttons. This is the PBASIC code to play the code back under control of your BASIC Stamp:

```
serout 4,188+$8000,[ "!SMOP",75]
'play sound at address 75 (4800 bps)
```

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